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# THE JOURNAL OF WILDLIFE MANAGEMENT

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THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 18 JULY 1954 NUMBER 3

# ETHICS IN WILDLIFE MANAGEMENT

*Olaus J. Murie*

Moose, Wyoming

When THE WILDLIFE SOCIETY was first conceived, it was provisionally spoken of as the "Society of Wildlife Specialists." I remember the discussion later on at the formal organization meeting, when the permanent title "THE WILDLIFE SOCIETY" was adopted as more appropriate for the complex field of interests and functions with which we might be concerned. Since then members have now and then questioned: "What are we for? Where are we going?" Such questioning in itself denotes progress of our professional organization. Further proof of our progress is the current attempt, by a series of appointed committees, to establish professional standards.

There are several aspects to any set of standards. One of these should be high purpose in our work.

Naturally we all have the practical objective of finding work to do—a job. We have taken our training because we wanted to "get into wildlife work," to get out in the woods, to get into conservation, or to get into research. Some of us "get into" administration. In this process some of us learn to know much about animal populations, waterfowl ecology, fisheries, wildlife diseases, or some other specialties. We become expert, more or less, in some field of knowledge of wildlife, broad or limited. This is basic and important, and for the sake of the future of wildlife we earnestly pray that such proficiency in wildlife management will become accepted by sportsmen and political bodies more generally than is now the case.

But from here on we have a choice, every one of us. We may be content to tinker with the machine, gather facts, do the repair jobs, do the routine management in the hope of merely maintaining certain game populations. When a train pulls into a junction you may see a flock of mechanics begin tapping wheels, washing windows, supplying ice. A worthy and necessary operation.

With wildlife it is not so simple. We are not only dealing with animals and plants and soil and water. We are dealing with people as well. Whether we like it or not, we find ourselves in the midst of a struggle. Thoughtful people are trying to understand our place in Nature, trying to build a proper social fabric, groping for a code of ethics toward each other and toward nature. The current controversies in the diverse field of conservation are an expression of this ethical struggle. We, as wildlife technicians, cannot escape it. As members of our profession we have a re-

sponsibility to contribute to the highest thinking in this field.

You may say: "Be specific. What do you have in mind?"

Let us consider hunting as it is practiced today. Most of us are more or less closely associated with this pastime. Our work is generally directed toward the maintenance of this sport. But are we satisfied with the general attitude of a large proportion of those who buy hunting licenses? Are we satisfied with the low standards, or lack of standards, that we encounter among those who carry guns?

There is a long background of trophy hunting, a tradition that, at its best, developed a set of standards into a sportsman's code that had some admirable elements profoundly affecting people everywhere. There are still those who reflect the gentlemanly behavior engendered by such a code. There are those who hunt, who are also sensitive to beauty and to the warmth of an outdoor experience. No doubt we all know such people. But what are we to think of the hordes of gun carriers, licensed to shoot something, who go afield with an indefinite lust that they themselves would not be able to define or understand, who shoot anything that comes in the line of vision, including each other, impatient of any obstacle or personal exertion, who want the game convenient to the car or airplane in the shortest possible time?

I remember that, many years ago, certain game wardens in Alaska used to size up and classify big game hunters as "sportsmen" and "killers." That is a nice distinction, considering that all of those hunters carried guns, but it is a valid one.

A few years ago an article appeared in a sportsmen's magazine, written by an attractive woman whose picture was prominently displayed with the African game she had killed. The title of her article was: "I like to kill things."

One time at a refuge some surplus buffalo were being killed for official disposal. The animals were driven into a chute, where they were dispatched humanely. An Army officer happened to be present, and as a courtesy to him he was invited to shoot one of the buffalo in the chute. He did, with the proffered pistol, at a distance of some three feet. So, he had killed a buffalo.

One reads advertisements to the effect that at certain ranches one may have the privilege (for a specified sum) to go out in the pasture to shoot a buffalo.

Also, certain "public spirited" commercial interests sponsor special fish derbies and sundry game shooting contests. Thus the dollar hungry predators infiltrate to further debase the recreation we know as hunting and fishing.

Some months ago I attended a local meeting to consider certain revisions of the game laws. It soon became evident that some of the proposals were designed primarily to benefit certain people financially. One person frankly stated: "Let's support local industry." (In this instance, guides and outfitters.) As a friend of mine remarked about a similar meeting: "The dollar sign shone in their eyes." At the same time there were scathing references to the "meat hunter."

All right, what of the so-called meat hunter? Aren't we nearly all meat hunters today? Is not hunting for meat,

combined with whatever else we are capable of absorbing in the process, from what remains of wilderness habitat, perhaps the most worthy purpose in hunting and fishing? Those who have travelled in real wilderness, prudently taking from the fauna and flora what is needful, primarily motivated by love of wild country, have truly experienced the highest purpose of hunting. Doesn't it, after all, depend on what attitude we have toward Nature?

Let us look at the brighter side. On one occasion the Jackson Hole Chapter of the Izaak Walton League in Wyoming passed a resolution denouncing the principle of the hunting contests for commercial gain as unsportsmanlike. Some members of the Outdoor Writers Association urged their fellow members to play down the importance of getting the bag limit; to stress quality of experience rather than quantity of game.

It is significant too that many hunters today are taking to the bow and arrow as a weapon, in an effort to regain some of the skill that used to be required to secure game.

But these are not the only things that concern us. There is also the non-hunting use of wildlife. Aldo Leopold loved to hunt and fish, but he was also a staunch defender of those raptores and carnivores which are too often condemned by a certain class of "sportsmen," and he sensed the value of song birds and wildflowers and trees, for their own sakes. We are struggling with new concepts, or perhaps better, giving new attention to ideas that have long been struggling for recognition. At the Third General Assembly of the International Union for the Protection of Nature in Venezuela, a committee of members from Switzerland, England, Venezuela and the United States endeavored to formulate a statement of our convictions on man's proper relation with Nature. Perhaps every race or nation throughout its existence has dealt with this, as revealed in religious, folklore, and cultural patterns. Today we are still trying to understand.

I believe that a code of ethics arises from the quality of our experience and our thinking. Since the time when we emerged from the irresponsible prehuman era we have had to tamper with our progress, consciously and purposely, with whatever wisdom we have been able to command. But evolution still operates. It is fortunate that we can't escape it. Esthetics in its many forms has evolved with us, affecting our judgments, shaping our way of life and our philosophy—and esthetics had its roots in organisms long before man developed it so highly. We have also nurtured an inherent concept of morals, and of responsibility. We are toying with the qualities of generosity and tolerance, a sense of neighborliness in the Nature of which we are a part. Note the thousands of bird-feeding trays, the bird walks, the wildflower preservation societies. We have become interested in game species for their own sakes, as interesting animals. It seems paradoxical, but true, that certain sportsmen of sensitive minds love the things they shoot. Appreciation of our competitors, the carnivores and birds of prey and certain rodents, comes much harder. But we are progressing there too. We have Hawk Mountain Sanctuary in Pennsylvania. Certain western cattlemen like to have coyotes around. This is linked with our heavy-footed progress

in toleration of "other" races of men. From the vantage point of history, in spite of recent murderous political madness, we see that charity may be slowly emerging.

It is always profitable to leave our own technical boundaries and explore what men have thought in other spheres of living. Emerson, as philosopher and literary genius of his time, was much concerned with Nature. His essay on "The Sovereignty of Ethics" is up to date and worth our attention: . . . . . "that can never be good for the bee that is bad for the hive. See how these things look in the page of history."

"The idea of right exists in the human mind, and lays itself out in the equilibrium of Nature, in the equalities and periods of our system, in the level of seas, in the action and reaction of forces."

Recently, in "Animal Kingdom", I read a letter from Aldous Huxley in which he speaks of "an ethical system comprehensive enough to include Nature as well as man."

In dedicating the monument to the passenger pigeon in Wisconsin, Aldo Leopold remarked: "But we, who have lost our pigeons, mourn the loss. Had the funeral been ours, the pigeons would hardly have mourned us. In this fact, rather than in Mr. DuPont's nylons or Mr. Vannevar Bush's bombs, lies objective evidence of our superiority over the beasts."

The more sensitive sportsmen long ago developed in their code a sense of fair play, and strove to give the hunted thing what they termed a "sporting chance."

Is this the road of man's spiritual travel? Are these the sign posts along the way: "the sporting chance," Emerson, Thoreau, Seton, Stewart Edward White, the Audubon Society, Izaak Walton and the League that uses his name, the many nature societies and associations, the Sand County Almanac, The American Nature Association, The Wilderness Society, the International Union for the Protection of Nature, The Wildlife Society? These are only random selections.

The Natural Resources Council is an attempt to give a common direction to diverse conservation impulses. We find the National Wildlife Federation helping to defend a national park, together with many other kinds of organizations. The Wildlife Management Institute does the same, and by the medium of its annual North American Wildlife Conference, has made much headway in bringing into closer understanding and concerted thinking the aspirations of many different groups of people.

I am not sure that we have agreed upon even a broad goal, but it is worth trying. Two viewpoints come to mind.

A number of years ago a group of us were standing on an elk-feeding ground in Wyoming, where hay was being doled out to the animals. Many of the elk looked unthrifty. A particularly old and decrepit cow elk came by.

"There is a poor specimen of an elk," someone remarked.

A game warden who was present said: "Oh well, she'll throw another calf for us this spring."

Worship of numbers. Counting, not weighing.

Then consider this. A field biologist, Robert L. Patterson, in the book "The Sage Grouse in Wyoming," given the publication award by our Society for

1952, expresses this belief:

"By now it should be an old and well-established principle that the primary consideration in game management should always be the welfare of the game species, with the sportsmen receiving an important but secondary consideration. Issues of palatability, law enforcement, damage control, etc., as related to time of game harvest, must necessarily be resolved without sacrificing the primary objective of management."

Here is one approach to a philosophy about our relation with Nature, which grants that Nature has a right to exist, and reveals generosity toward wildlife, and tolerance for the views and desires of many people. Here is a spacious philosophy which finds room for the scientist, the hunter and fisherman, the nature lover; room for wild alert creatures in the home of their own choosing, the "good oak", the pine, the sage, a bit of original prairie, a mountain landscape with its original content.

Granted such a big-hearted code of ethics to include ourselves and Nature, could we find a place in it for extensive replacement of native species of game by exotic ones, for the satisfaction of a special interest group, without the concurrence of other users of Nature's domain? Our code as here suggested conceives of democracy as a way of life, a sportsman's consideration of the rights and sensitivity of fellow beings, as well as appreciation and regard for the native scene.

Does all this appear too complicated and unnecessary? Perhaps it seems more important to be a good technician, to know the biological answers and let someone else fuss with social trends. But some of us become administrators and are up against making decisions in policy. I have seen young technicians falling into the pitfalls of slanting their information, innocently enough, to suit politically minded superiors. We have the choice as a profession: We may be content to expertly tinker with the wildlife machine to keep it alive somehow; or we can give our profession the dignity and importance it deserves and help the public interpret the facts so as to contribute in man's struggle to find himself.

Perhaps many have already made this decision. To refer again to the most recent research report at hand, "The Sage Grouse in Wyoming", I find this statement:

"It is anticipated that some criticism will be directed against the elements of this study which depart from purely natural history and ecological phases. The most exacting knowledge of an animal's life processes by itself is valueless in an evaluation of its chances for survival in the atomic age. The various land-use policies and political expediencies ultimately set the tolerance limits for the survival of any wildlife species. The sage grouse provides no exception to this principle. This monograph would have been erroneously conceived and derelict in its presentation if the effects of an expanding civilization upon sage grouse populations had not been fully explored and appraised."

Our training in the universities should be such that we do not come out pretty good technicians but philosophical illiterates. We need to look up from our technical study at times and look at the horizon. Evolution is our employer.

# ESTIMATING THE PERCENTAGE KILL IN RINGNECKED PHEASANTS AND OTHER GAME SPECIES

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We commonly strive to determine population sizes of pheasants as an aid to management. Allen (1942), Kelker (1945) and Petrides (1949), have all prepared formulas with this end in view.

Often, however, it is of even more immediate importance to know the percentage of the shootable population which has been killed. This would permit an appraisal of effectiveness of current regulations, which should be directed toward permitting maximum allowable kill without exceeding that amount.

The methods reported here for estimating percentage kill appear to be especially useful over large areas. Like the formulas presented in the publications cited above, they depend upon comparisons of sex ratios before and after the open season and in the kill. They differ, however, in that they do not require total kill figures. The compared ratios must either be true ones or be subject to equal bias. In some cases, the preseason ratio possibly may be estimated without field checks and where only cocks are killed the sex ratio in the bag also may not require field checks (but see beyond).

The easiest approach seems to be to determine numbers of males per 100 females by random field counts or roadside observations. These may be compared as in the following example where cocks only are killed:

| | Males per 100 females | Percentage kill |
|---|---|---|
| Preseason..... | 80 | |
| Postseason.... | −25 | |
| | 55 | 55/80×100 = 69% |

Where females also are shot and proportions of the sexes in the kill (but not the total kill) are shown, a table may be set up of the numbers of males per 100 females in each category. For example, where symbols for each category also are provided:

| Proportions | Males | Females | Totals |
|---|---|---|---|
| Preseason | 80 (=$M_1$) | 100 | 180 = P |
| Kill sample | 300 (m=.75) | 100 (f=.25) | Unknown = K |
| Postseason | 25 (=$M_2$) | 100 | ..... |

From these data, it is possible to calculate the relative extent of the kill.

Where (mK) and (fK) are the unknown relative numbers of males and females in the kill and where the data are in terms of males per 100 females, the proportion may be established:

$$\frac{M_1 - mK}{100 - fK} = \frac{M_2}{100}$$

Solving for K, the total kill relative to the preseason population:

$$K = \frac{100\,(M_1 - M_2)}{100m - fM_2}$$

Substituting the relative numbers and proportions given in the above example:

$$K = \frac{100\ (80 - 25)}{100 \times .75 - .25 \times 25} = 80$$

This indicates that relative to the preseason population level of 180, a kill of 80 has been accomplished. The relative kill of each sex also can be determined. For males, this is $.75 \times 80 = 60$ and for females $.25 \times 80 = 20$. These relative kill figures then may be substituted in the original table. Their relation to the preseason data is made evident and the postseason relative numbers are determined by subtraction:

| | Males | Females | Totals |
|---|---|---|---|
| Preseason.... | 80 | 100 | 180 |
| Kill..... | −60 | −20 | −80 |
| Postseason .. | 20 | 80 | 100 |

The percentages of kill in the various categories may be determined:

Males: $60/80 \times 100 = 75.0\%$
Females: $20/100 \times 100 = 20.0\%$
Total: $80/180 \times 100 = 44.4\%$

Admittedly, it is not the best practice to attempt to arrive at an autumn sex ratio figure without field data for that season. But where previous spring sex ratios are known (or can be approximated from previous postseason ratios) and where the extent of reproductive success is known, it would seem possible to often come rather close to the facts in estimating preseason sex ratios.

Under favorable reproductive conditions the great preponderance of young in the population are about equally divided by sex and would tend to create a nearly balanced total sex ratio before the open season. Thus, for example, where cocks comprised about 20% of the spring population and where 6 young per adult hen survived until August, a fall sex ratio of about 80 males per 100 hens would be probable where no unbalanced losses occurred in one sex of the adults. Use of such calculations would seem to be warranted at least where better estimates are not available.

Where cocks only are killed, the simple computations given at the beginning of this article may suffice. But in view of usual losses in hens due to careless and illegal hunting, probably a regular estimate of female losses is desirable even though only males are legal game. If a 15% loss of hens can be assumed, for example, this provides the figures $f = .15$ and $m = .85$ representing the sex ratio in the kill.

In Ingham County, Michigan, in the area between East Lansing and Mason, postseason roadside counts of pheasants from early December 1951 to early January 1952 yielded 147 cocks and 580 hens for a ratio of 26 cocks per 100 hens. Assuming an 80 : 100 preseason sex ratio and an incidental kill of females equal to 15% of the total bag:

| | Males | Females | Totals |
|---|---|---|---|
| Preseason ... | 80 | 100 | 180 |
| Kill..... | m = .85 | f = .15 | |
| Postseason .. | 26 | 100 | |

K is calculated from the formula above:

$$K = \frac{100\ (80\text{–}26)}{100 \times .85 - .15 \times 26} = 66$$

And the relative kill of males is $.85 \times 66 = 56$. Whence the estimated percentage kill of males during the 1951 season in that area was $56/80 \times 100 = 70\%$ and of both sexes was $66/180 \times 100 = 36\%$.

Most frequently the percentage kill of males ($k_M$) is the item which is of most interest and value. A formula for its calculation would be $k_M = mK/M_1 \times$

100, as per the examples given in the last two paragraphs. Combining this formula with the earlier one which permitted the calculation of K:

$$k_M = \frac{10000\ m\ (M_1 - M_2)}{M_1\ (100\ m - fM_2)}$$

For convenience, however, a table has been prepared giving the percentage kill of males where sex ratios before and after the open season are known and where the percentage kill of females can be estimated. To estimate table values for intermediate female kill percentages or sex ratios one may prorate the table values with little inaccuracy.

While the methods here discussed probably are of most general use in pheasant management, they would seem to be applicable also to other species where individuals can be easily identified in the field as to sex or age after as well as before the open season. The procedures should be useful for antlered game, wherever one sex is harvested to a greater extent than the other. Where relative numbers of young and adults can be determined, these age data can be substituted directly in the formulas for the male and female relative num-

TABLE 1.—PERCENTAGE KILL OF MALES BY COMPARISONS OF PRESEASON AND POSTSEASON SEX RATIOS

| Postseason Males/100 females ($M_2$) | | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Preseason Males/100 females ($M_1$) | | | | | | | | | | |
| | % Kill females | | | | | | | | | |
| 100 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| | 10 | 11 | 22 | 33 | 43 | 53 | 63 | 72 | 82 | 91 |
| | 20 | 13 | 25 | 36 | 47 | 57 | 67 | 76 | 84 | 92 |
| | 30 | 16 | 30 | 43 | 53 | 63 | 72 | 80 | 88 | 94 |
| 90 | 0 | .. | 11 | 22 | 33 | 44 | 56 | 67 | 78 | 89 |
| | 10 | .. | 12 | 24 | 36 | 47 | 57 | 69 | 80 | 90 |
| | 20 | .. | 14 | 27 | 39 | 51 | 62 | 72 | 82 | 91 |
| | 30 | .. | 17 | 32 | 45 | 57 | 67 | 77 | 85 | 93 |
| 80 | 0 | .. | .. | 13 | 25 | 38 | 50 | 62 | 75 | 87 |
| | 10 | .. | .. | 14 | 27 | 40 | 52 | 64 | 77 | 88 |
| | 20 | .. | .. | 15 | 29 | 43 | 56 | 69 | 79 | 90 |
| | 30 | .. | .. | 18 | 34 | 48 | 60 | 72 | 82 | 91 |
| 70 | 0 | .. | .. | .. | 14 | 29 | 43 | 57 | 71 | 86 |
| | 10 | .. | .. | .. | 15 | 30 | 45 | 59 | 73 | 87 |
| | 20 | .. | .. | .. | 17 | 33 | 48 | 62 | 75 | 88 |
| | 30 | .. | .. | .. | 19 | 36 | 52 | 66 | 78 | 90 |
| 60 | 0 | .. | .. | .. | .. | 16 | 33 | 50 | 66 | 83 |
| | 10 | .. | .. | .. | .. | 18 | 35 | 52 | 68 | 84 |
| | 20 | .. | .. | .. | .. | 19 | 37 | 54 | 70 | 85 |
| | 30 | .. | .. | .. | .. | 21 | 40 | 57 | 73 | 88 |

bers used here. In the case of antlered game both sex and age data possibly could be used, checking the results of one against the other. Sex ratio procedures similar to the above also could be used to determine the excess losses of females during the reproductive season.

I wish to express my thanks to Drs. Don Hayne of Michigan State College and George Kelker of Utah State Agricultural College for reviewing an early manuscript of this paper.

## SUMMARY

Formulas and a table are presented which permit the ready estimation of the percentage kill of male game animals where that sex is hunted discriminately and where sex ratios before and after the hunting season are known or can be estimated. Formulas also permit estimations of the percentage kill of females and of both sexes.

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# A PRELIMINARY REPORT ON A METHOD OF ESTIMATING REEF FISH POPULATIONS

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## INTRODUCTION

On the basis of food habits and estimated size of the human population, the reef fisheries were likely exploited heavily in Hawaii before Captain Cook's first visit to these islands. There was also at that time, a concomitant code of restraints which apparently served to maintain the productivity of these fisheries (Titcomb, 1951). With the imposition of new cultural patterns and immigration of new peoples, the earlier adjustments among rates of exploitation and rates of replenishment of stocks of reef fishes were probably lost, since catches of many species landed in island markets declined, at least for the period after 1900, for which some statistical information exists. Today, in the opinion of many fishermen and on the basis of changes in amounts of fish from reef fisheries landed in local markets, there has been a considerable decrease in the availability of some of these fish. Such a decrease may continue. The studies reported on here were begun to supply some of the information necessary to restore these fisheries to former levels of productivity. This, of course, applies equally well whether concern is felt regarding either commercial or sport fisheries.

The problem of measuring abundance of fish in the sea and other bodies of

water has been most troublesome, yet its solution is fundamental to the adequate management of a fishery. Without some knowledge of the size of the fishable stock and the magnitude of changes in it occasioned by fishing, the effect of management practices and changes in regulations governing activities of fishermen cannot be discerned; in fact if some method is not available to measure the results of management or regulations, any justification to manage or regulate disappears.

The conventional methods of measuring fluctuations in the abundance of fish populations ordinarily use fluctuations in the productivity of existing fisheries or a consideration of the ratio of tagged or marked fishes released to those recovered and the total catch per unit time. In restricted bodies of water it is sometimes possible to estimate the abundance of fish populations by seining or gill netting, in effect, by operating a fishery solely for the purpose of estimating abundance (Allen, 1951).

Adequate methods of estimating abundance based on fishing success are often difficult to devise since ordinarily the catch of fish depends upon a number of factors among which is the one of interest-abundance. In a recent unpublished study of the catch of skipjack in Hawaii per boat per day for weekly periods during the 1952 summer season, a surprisingly high correlation ($r = .73$) between the catch and the mean length of the fish measured at the cannery was found. Here it would seem that fluctuations in fishing success was largely determined by the sizes of fish available on the fishing grounds. Tagging a known number of fish and observing the ratio of tagged and untagged individuals in the catch may obviate some of the difficulties of using estimates based on the catch per unit of effort, but the tagging method ordinarily involves numerous practical difficulties in application.

Methods of estimating abundance which depend upon sampling a population or some measurable fraction of it practically completely—such as the total draining of a lake or the use of fish poisons to obtain the fish, have the virtue of simplicity, but from a practical standpoint can be applied only in certain special situations other than in small bodies of water. They also have the effect of "curing the disease but killing the patient" in the sense that the population measured is also eliminated. However, fish poisons were used in estimating the abundance of reef fishes on the open shallow reef at Bikini in 1946 and 1947 (Schultz 1948).

Methods of estimating abundance which do not necessitate the death or capture of some part of the population may give an index which is more simply related to the population sizes than those that do, providing certain requirements can be met: (1) that individual fish or schools be detected in a quantitative way, (2) that the proportion of fish so detected can be evaluated in relation to the whole population or to an area, if the population is randomly distributed, or if not, its distribution must be known, and (3) that accurate distinctions among species be possible.

There have been attempts to evaluate the abundance of fish populations by sighting schools either from ships or aircraft as described for Australian waters by Blackburn and Tubb (1950). Since only those schools of fish which

are visible at the surface of the sea can be enumerated, it is easy to visualize situations in which this method would give a measure that bore a widely varying relationship to abundance from time to time and place to place. However, certain Australian species had a sufficient degree of internal consistency to make the method seem worthy of attention.

The employment of sonar apparatus of proper design might serve as a possible way of estimating abundance of fishes so as to fulfill the requirements listed above. Under proper circumstances the employment of automatic submarine cameras or submarine television cameras might serve the same purpose. And, under proper circumstances, a diver could enumerate fishes seen so that estimations of abundance could be made. The present paper is concerned with a description and a preliminary evaluation of an application of this last-mentioned method to coral reef and shallow-water fish populations.

## ACKNOWLEDGMENTS

This method of estimating reef fish populations was developed under Project F5R, Federal Aid for Fish Restoration. The fisheries staff of the Division of Fish and Game of the Territory of Hawaii contributed to it, the contributions of Mr. Yoshio Yamaguchi and Mr. Georges Gilbert being particularly worthy of mention.

## MATERIALS AND METHODS

Two divers equipped with self-contained compressed air diving apparatus of the type developed by Cousteau and Gagnan (Cousteau 1953), swimfins, face mask, a squeeze-actuated rescue pack and optionally with a knife and/or a zipper-closed collecting bag would swim along a five-hundred-yard line previously laid across the sea floor, and count the fish seen. The counting path for each diver was approximately twenty feet wide and as long as the line. A record of the counts was kept on a white frosted plastic sheet six inches wide by nineteen inches long. Both sides of the frosted plastic sheet were ruled horizontally in spaces about 3/8″ in width, and vertically into six portions, one for the names of fishes, the other five for entering the numbers and estimated lengths of fish seen in each one-hundred-yard section of the line. The names of fish likely to be seen were entered on the initial section in family groups. Vacant spaces were left at the end of each family group so that additional names of fishes could be readily added in the field and also for notes on water depths, nature of bottom, and associated flora and invertebrate fauna. A lead pencil, wrapped with string to prevent disintegration in water, was tied to the plastic pad for taking notes.

Also required is a surface crew of at least two men together with a skiff, outboard motor, three light anchors, two buoys and a pair of oars.

The procedure of making counts was to select a suitable average site by consulting charts and then scouting the approximate locality.

One a site had been decided upon, the transect line was laid from the skiff. The line used was ordinary cotton wrapping twine and was weighted by small seine leads attached at fifty-yard intervals. On every other lead weight, that is for each hundred yards of line, a numbered ribbon marker was attached

which made it possible for the divers to correctly ascertain the sequence of any section of line. One end of the line was made fast to a buoyed anchor and then, as the skiff proceeded, the line was paid out, stretched tightly. At the far end the line was fastened to another buoyed anchor. Thereupon the two divers entered the water and, once the skiff was again underway, swam one on each side of the transect line. Each diver enumerated by species and length all fish sighted within a band or zone extending some twenty feet out from the line. In the meantime the skiff maintained a station in the immediate vicinity of the divers, whose position was marked by a foamy patch of bubbles on the surface. One crewman aboard the skiff had the responsibility of keeping the patch of air bubbles under constant observation, the other of operating the motor and piloting.

The divers, during the course of counting out the transect line had the additional responsibilities of watching each other and also the skiff.

In order to obtain uniformity in counting, each diver would enumerate only those fish within the twenty-foot-wide band immediately ahead of him on only his side of the transect line. If a school of fish should enter the band at a point where he was counting and cross the band, all members of the school would be counted. If the school entered the transect area behind the diver, its members were not counted. If a school of fish were recognized as it entered the area for a second time, its members were not again enumerated.

In general the fishes could be assigned to one of the three following categories: (1) resident species, (2) wandering schooling species, and (3) solitary wanderers. Variations in the number of fishes found on a transect band in repeated counts would, as a rule, be most effected by variations in the chance encounters of schools of the wandering schooling species.

In making an analysis of the estimated lengths, a transformation of lengths into weights was made by the equation: $W = A (L^3)$. W represents the weight of the fish, L the length and, A a species constant based on known weights and lengths for the species involved. The estimates of the weights thus determined were multiplied by the number of such fishes counted to determine the total weight of each species and these values, when summed, the total weight of fish observed within the transect area. Mean weights were also computed.

Data concerning some 17 transects made in accordance with procedures described above are discussed in this paper. These transects were conducted in nine localities which were selected in order to sample a variety of environmental situations. These localities are briefly described in the same order as they are presented in Figure 1.

Keahole Point Station, near deep water on the Kona Coast of Hawaii, had a remarkable abundance of fish such as the opelu kala (*Naso hexacanthus*), scarids and midwater pomacentrids. A good population of *Zebrasoma flavescens*, a species characteristic of lee reef areas was present. The nanue or rudder fish, (*Kyphosus bigibbus*) together with two species of snappers, the nuku nuku waha nui (translated from Hawaiian "Big-mouthed growler") (*Aphareus furcatus*) and the mu (*Mono-*

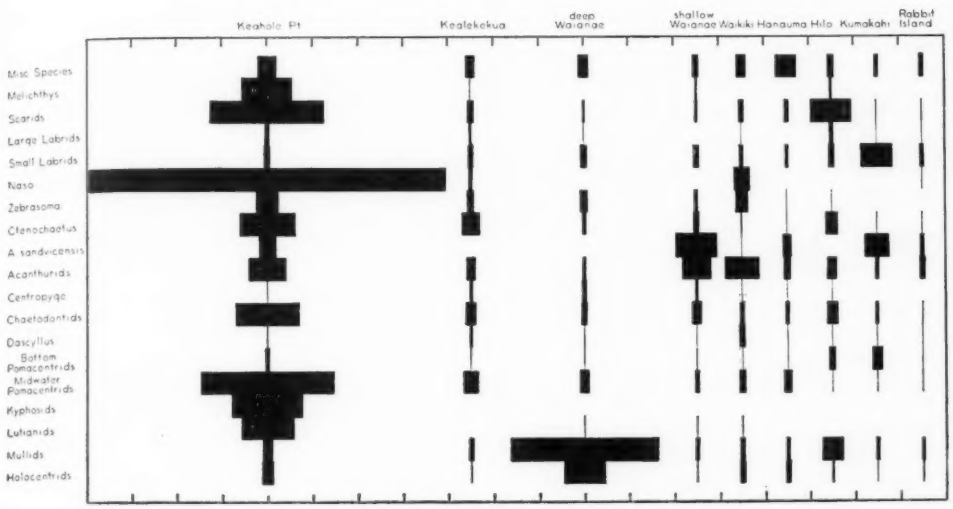


FIG. 1. Species composition by estimated weights of fishes observed along transects in nine localities around the islands of Hawaii and Oahu. Each vertical division represents 100 pounds.

*taxis grandoculis*) were abundant, while in contrast they were absent from the station in Kealekekua Bay which likewise is on the Kona Coast of Hawaii in about the same water depths. *Zebrasoma flavescens* was also common at the Kealekekua Bay Station. The deep Waianae station was characterized by a large school of weke ula or red goatfish (*Mulloidichthys auriflamma*) and while the numbers of these schools are small enough to make the inclusion of one in transect counts a rare event, a school of this species was encountered during both of the deep Waianae counts at a spot that was the same within 20 feet or less, yet the two counts were over five months apart. Here, the natural history of the fish concerned is of particular significance. The weke ula commonly forms resting aggregates or schools during the day. At such times the fish hang quietly in dense masses ten to fifteen feet above bottom. While they can be netted in such schools, it is impossible to get them to take any bait. The feeding apparently takes place only at night. Such resting schools of weke ula are reported by fishermen to reform in precisely the same place for extended periods of time. The deep Waianae Station also contained an unusual abundance of holocentrids especially the uu (*Myripristes murdjan*), a valued food fish. The shallow Waianae Station had a greater abundance of acanthurids especially manini (*Acanthurus sandvicensis*); it was almost immediately inshore of the deep Waianae Station and both were at right angles to the coast. The two Waianae Stations as well as the one off Waikiki also had a good population of *Zebrasoma flavescens*; these stations were all on the leeward side of Oahu. The greatest abundance of *Dascyllus albisella* for any counts was found at Waikiki; this species is characteristic of the area of relatively flat bottom with occasionally scattered coral heads such as occurs in

much of the area between Koko Head and Barbers Point on Oahu.

The pattern of distribution of species for the Hanauma Bay Station indicated that it was essentially a "windward" area, in that *Zebrasoma flavescens* was not common yet this species was commonly found at all leeward stations. The weight of the fish in a school of opelu, *Decapterus pinnulatus* accounts for a large portion of that shown as miscellaneous species in Figure 1 (44 pounds). Schools of this species might be expected to occur at all stations except Kumakahi in Puna.

The Hilo Station was located on the windward side of the Island of Hawaii off the inner end of the Hilo Harbor breakwater. This area possessed a good population of large parrot fishes, goat fishes, surgeon fishes, butterfly fishes, and a bottom-dwelling damsel fish (*Pomacentrus jenkinsi*). Midwater damsel fishes were not abundant, and unlike the leeward area station, neither was *Zebrasoma flavescens*.

The station at Kumakahi in Puna, a windward area, in addition was located in a shoal-protected area behind an elongated patch of reef. The average size of fish was small and dominant species groups were small labrids, largely *Thalassoma duperrey*, small manini (*Acanthurus sandvicensis*) and bottom dwelling damsel fishes, largely *Pomacentrus jenkinsi* and *Abudefduf imparipennis*.

The Rabbit Island stations were located between Rabbit Island, a small windward islet, and Oahu. The bottom was level, largely a thin layer of sand or coral gravel over rock and with a relatively scant population of fishes. The dominant species groups were surgeon fishes, small labrids or wrasses, goatfish, and, shown in Figure 1 in the miscellaneous species group, the Humuhumu-nuku-nuku-a-puaa, or trigger fish (*Balistapus rectangulus*). It is of interest that on the seaward side of Rabbit Island where the water deepens rapidly to from 60 to 70 feet, an abundant population of fish exists made up of such species as *Naso hexacanthus* large parrot fishes, snappers (*Monotaxis grandoculis*), rudder fish, a species complex which while not as abundant, resembles in some respects that found at the Keahole Point Station. A transect was not conducted in this last-mentioned area; an appraisal of it is based on observations made while collecting fishes by spearing.

The relationship of abundance to fishing pressure is, of course, a matter of major concern. Adequate data on fishing pressures are not available for these areas. The Keahole Point Station by reason of its remoteness and inaccessibility except from the sea was likely the least-fished station. The deep Waianae and Hilo stations were probably only lightly fished because of excessive depths and/or long periods of rough seas. All the other areas were probably subjected to somewhat more fishing pressure by net, trap, and spear as well as by hook and line. In general, however, it is likely that marked differences among stations in kinds and numbers of fish found was a result of biological or physical differences in the environment among these stations. And it may be suspected that the imposition of a heavy and possibly selective fishing pressure would shift but not obscure these differences.

It is obvious that visual transects

must be confined to reasonably clear water; a visual range of ten feet would constitute an absolute minimum. The method is limited to relatively shallow water (60 - 100 feet) unless troublesome preparations are taken to offset the problems which come with diving to increased depths. It is necessary to select a transect site with great care since it ordinarily constitutes such a small sample (60,000 sq. ft.) of the bottom. In this regard it may be desirable to develop a method which permits a much longer transect, accepting, if necessary, somewhat reduced accuracy in order to increase sample size. For some applications in estimating abundance the relatively minor part of the fishing grounds that can be covered may constitute the major objection to this method. The comparatively sedentary habit of most reef fish species does lessen the force of this objection.

In the discussions which follow, it has been implicitly assumed that estimated numbers and weights of fish observed on a transect constitute a measure of the stock of fish present. The validity of this assumption depends, of course, on the magnitude of the systematic errors that may be associated with the method. Those errors are likely to be, aside from errors of counting, of estimating size, the so-called "observer error", to be due to (1) failure to find fish which normally reside in holes or cavities. It is likely that those species normally living in such habitats, such as eels, squirrel fish and cardinal fish are usually underestimated; and (2) failure to see alert and cautious species which may leave the transect area long before the divers see or reach them. This may occur for sharks. However, in general, there has been no evidence that fish were alarmed by the divers. The possibility of not sighting fish at the surface while divers are near the bottom is not a likely source of error, at least for the transects described here. The divers are free swimming and therefore range ordinarily well clear of the bottom and in 40 feet of water or less have been able to observe fish from the surface to the sea floor. Fish have not been observed near or at the surface in all such transects. In any case, the number of fish observed and recorded are likely for all these reasons and others not to exceed the number actually occurring in the transect area and they well may be somewhat less. The estimates of stock of fish may therefore be conservative.

The problems associated with training personnel to conduct transects competently and safely are time consuming but otherwise have not proven difficult. Training in the proper method of handling the diving apparatus and in accurate sight identification of about 125 species of fish were the principal tasks. A memorandum concerning procedures to be followed in conduct of a transect was prepared and rigidly adhered to in order to minimize risks to divers from apparatus failure, caisson disease, or air embolism.

## RESULTS

This scheme for estimating populations was first tried in late winter of 1952. Some 18 transects were run during 1952 and early 1953; 17 of these in which the procedures were sufficiently alike to permit adequate comparisons are discussed.

A summary of fish numbers and corresponding estimated weights for transect

counts discussed is listed in Table 1. The differences among duplications are, considering the nature of the measure, surprisingly small except for Keahole Point and Waianae (deep). If the fish counted at both of these localities are placed into these three groups: (1) resident species, (2) wandering schooling species, and (3) solitary wandering species, it may be seen that the greater part of the difference between the Keahole duplications could be assigned to the group of wandering schooling species as shown in Table 2.

The differences between the resident species counts for Keahole Point is remarkably low; the corresponding difference for the deep Waianae duplicate is much greater. However, there are two factors which would help to ex-

Table 1.—Summary of fish seen in 17 transects, with dates of observation, calculated weights, standing crops, depths and descriptions of transect, and pertinent remarks

| Locality | Date | No. of Fish Counted | Calculated Weight Pounds | Mean Weight of Fish | Calculated Pounds per Acre | Depths in Feet | Bottom | Remarks |
|---|---|---|---|---|---|---|---|---|
| Keahole Pt., Kona | 9/28/52 | 6417 | 2917 | .45 | 2118 | 30–28 | Rock—boulders and coral | On same line |
| " " " | 9/26/52 | 2765 | 1636 | .59 | 1188 | 30–28 | | |
| Average | | 4591 | 2276 | .50 | 1653 | | | |
| Waianae (Deep) | 8/29/52 | 1503 | 709 | .47 | 515 | 80–20 | Rock & coral, some small sand patches | On same line |
| " " | 3/11/52 | 1176 | 313 | .27 | 227 | 80–20 | | |
| Average | | 1339 | 511 | .38 | 371 | | | |
| Hilo | 9/24/52 | 786 | 263 | .34 | 191 | 35–20 | Rock & coral | |
| Waikiki | 1/22/53 | 984 | 255 | .26 | 185 | 60–40 | Some rock & coral, mostly thin sand over rock | Second Waikiki count 200 yards farther inshore |
| " | 3/12/53 | 1276 | 224 | .18 | 163 | 65–33 | | |
| Average | | 1130 | 239 | .22 | 174 | | | |
| Waianae (Shallow) | 3/6/52 | 1116 | 250 | .22 | 182 | 33–9 | Rock & coral & sand patches | Same area—Line positions overlapped in part |
| " " | 3/31/52 | 973 | 244 | .25 | 177 | 27–16 | | |
| Average | | 1044 | 247 | .24 | 179 | | | |
| Kealekekua Bay | 9/27/52 | 1658 | 178 | .11 | 129 | 35–25 | Rock & coral with sand | |
| Kumakahi Puna | 9/23/52 | 1623 | 176 | .11 | 128 | 20–3 | Rock & sand little coral | |
| Hanauma Bay | 9/11/52 | 819 | 137 | .17 | 100 | | ½ over sand some rock & coral | |
| Rabbit Island | 8/19/52 | 465 | 114 | .25 | 83 | 40–18 | Rock & sand | Outer channel |
| " " | 3/19/52 | 340 | 55 | .16 | 40 | 30–16 | Largely sandy, occasional rocky ledge or coral head | These counts are fairly comparable, but only 2/27 & 2/29 on same counting line |
| " " | 2/27/52 | 126 | 54 | .43 | 39 | 30–25 | | |
| " " | 2/29/52 | 82 | 20 | .24 | 15 | 30–25 | | |
| " " | 10/16/52 | 77 | 9 | .12 | 7 | 26–20 | | |
| Average | | 218 | 50 | .23 | 36 | | | |

Table 2.—Comparison of species groups at Keahole Point and Waianae (deep) at two different dates for each location, with numbers and weights of fish observed

| Locality | KEAHOLE POINT | | | | WAIANAE (DEEP) | | | |
|---|---|---|---|---|---|---|---|---|
| Date | 9/26/52 | | 9/28/52 | | 3/11/52 | | 8/29/52 | |
| | No. | Weight | No. | Weight | No. | Weight | No. | Weight |
| | | lbs. | | lbs. | | lbs. | | lbs. |
| Resident Species | 1582 | 538 | 1650 | 516 | 534 | 110 | 717 | 194 |
| Wandering Schooling Species | 904 | 889 | 4288 | 2084 | 522 | 186 | 737 | 498 |
| Solitary Wanderers | 279 | 209 | 479 | 317 | 120 | 17 | 49 | 17 |
| Total | 2765 | 1636 | 6417 | 2917 | 1176 | 313 | 1503 | 709 |

plain the great difference at Waianae: (1) the fact that some five months intervened between the two Waianae counts, and (2) that the first Waianae count was made during the training period of personnel in this method and while the field procedures were being worked out.

The situation depicted by data listed in Table 2 has several implications. It would appear that portion of the fish population occurring in large wandering schools is likely to be estimated rather erratically by only a single transect and that the error to be assigned to the divers themselves, the "human error", is probably of much less importance as compared to that occurring through chance variation in the distribution of wandering fish schools at least for duplications that are fairly close together in time.

In any case, differences among duplicates for a locality are much less than the differences among localities (Table 1).

It appears pertinent to compare standing crop estimates obtained by the transect method described here with that procured by the use of other methods. Unfortunately, while such data are not available for marine situations they are published for freshwater lakes. Carlander (1950) listed data on weight of fish per acre for freshwater lakes. A comparison of those data rearranged with estimates obtained from transects is shown in Table 3.

Table 3.—Weights of fish in pounds per acre at various weight ranges for freshwater lakes in the United States and for Hawaiian reefs

| Weight In Pounds per Acre | No. of Lakes | No. of Reef Localities |
|---|---|---|
| 5 - 9 | 1 | |
| 10 - 19 | 7 | |
| 20 - 39 | 13 | 1 |
| 40 - 74 | 15 | |
| 75 - 149 | 96 | 3 |
| 150 - 299 | 48 | 3 |
| 300 - 599 | 96 | 1 |
| 600 - 1199 | 24 | |
| 1200 - 2800 | 2 | 1 |

While a comparison of results obtained from reef transects and data concerning weights of fish in freshwater lakes seem to show the same pattern of distribution, such a correlation is likely fortuitous and depends largely upon the nature of localities in which transects were run. However, range of magnitude of standing crop would seem to be about the same. Some inshore and reef areas were as barren of fish as the

poorest lakes and some would seem to sustain a stock as large as the richest lakes.

The association among particular species of coral reef fishes and characteristic habitats or niches has been described in general terms by Weber (1913) and for the shoal waters of a small New Caledonian islet in detail by Catala (1950). The existence of a definite pattern of distribution of most species in relation to bottom topography was frequently observed. This characteristic of many species of fishes in restricting their habitat to certain features of bottom or to certain water levels must, of course, have a major effect upon their abundance, potential or otherwise. Consideration here has been restricted to fish faunal complexes as associated with various transect localities. Kinds and weights of fish differed sufficiently for each locality wherein a transect was conducted so that each of these localities was, in some respect of its fauna of fishes, unique (Figure 1). A deliberate effort to select localities deemed representative of a wide variety of environmental situations may have been responsible for this wide variation among transects. However, in five of nine localities duplicate transects were made and, in general, were in good agreement. The fact that differences among localities seemed to be large in both number and estimated weight of fish and in species composition would, therefore, appear to be real. While it was not possible to relate abundance of fish and species composition to fishing pressures since data for fishing pressure were not adequate, this difference among localities might largely be the result of environmental differences among the localities themselves.

## SUMMARY

A method of estimating number and weight of reef fish by means of submarine counts and length estimates is described. The method involves the use of self-contained compressed-air diving apparatus by two divers, each counting all fish seen in a path 20 feet wide by 1,500 feet long thus covering a combined area of 60,000 square feet.

Some 17 trials of the method at nine different localities has indicated that estimates of stocks of fish present would seem to be sufficiently consistent to make the method useful.

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## APPENDIX A

## LIST OF SPECIES INCLUDED IN SPECIES GROUPS OF FIGURE 1

HOLOCENTRIDS
- *Holocentrus sammara*
- " *spinifer*
- " *scythrops*
- " *diadema*
- " *xantherythrus*
- *Mypristes murdjan*
- " sp.
- *Apogon frenatus*
- " sp.
- *Priacanthus cruentatus*

MULLIDS
- *Mulloidicthys samoensis*
- " *auriflamma*
- " sp.
- *Pseudupeneus pleurostigma*
- " *multifasciatus*
- " *bifasciatus*
- " *porphyreus*
- " *chryserydros*

LUTIANIDS
- *Aphareus furcatus*
- *Monotaxis grandoculis*
- *Aprion verescens*

KYPHOSIDS
- *Kyphosus bigibbus*

MIDWATER POMACENTRIDS
- *Chromis verator*
- " *ovalis*
- " *leucurus*
- " sp.
- *Abudefduf sordidus*
- " *abdominalis*

BOTTOM POMACENTRIDS
- *Abudefduf imparipennis*
- *Pomacentrus jenkinsi*

DASCYLLUS
- *Dascyllus albisella*

CHAETODONTIDS
- *Forcipiger longirostris*
- *Hemitaurichthys zoster*
- " *thompsoni*
- *Chaetodon fremblii*
- " *quadrimaculatus*
- *Chaetodon ornatissimus*
- " *trifasciatus*
- " *auriga*
- " *lunula*
- " *unimaculatus*
- " *miliaris*
- " *punctato fasciatus*
- *Holocanthus arcuatus*
- *Hemochus acuminatus*
- *Zanclus cornutus*

CENTROPYGE
- *Centropyge potteri*

ACANTHURIDS
- *Acanthurus guttatus*
- " *bariene*
- " *achilles*
- " *olivaceus*
- " *leucopareius*
- " *fuliginosus*
- " *elongatus*
- *Zebrasoma veliferum*
- *Acanthurus sandvicensis*

CTENOCHAETUS
- *Ctenochaetus strigosus*
- " *hawaiiensis*

ZEBRASOMA
- *Zebrasoma flavescens*

NASO
- *Naso lituratus*
- " *unicornis*
- " *hexacanthus*
- " *brevirostris*

SMALL LABRIDS
- *Cheilio inermis*
- *Comphosus tricolor*
- " *varius*
- *Thalassoma duperrey*
- " *umbrostigma*
- " *trilobata*
- " *fuscum*
- " *ballieui*
- *Labroides dimidiatus*
- *Stethojulis albovittata*
- " *axillaris*

APPENDIX A (continued)

*Cheilinus unifasciatus*
" *bimaculatus*
*Coris gaimardi*
" *flavovitatta*

LARGE LABRIDS
*Bodianus bilunulatus*
*Cheilinus rhodochrous*

SCARIDS
*Scarus formosus*
" *ahula*
" *cyanogrammus*
" *perspicillatus*
" *dubius*
" sp.
*Leptoscarus viridescens*

MELICHTHYS
*Melichthys buniva*

MISC. SPECIES
*Dasyatis brevis*
*Conger cinereus*
*Gymnothorax flavomarginata*
" *undulata*
" *meleagris*
" *petelli*
" sp.
*Echidna nebulosa*
Ophichthid eel
Echelid eel
*Trachenocephalus myops*
*Saurida gracilis*
*Fistularia petimba*
*Aulostomus chinensis*
*Caranx stellatus*
*Caranx sexfasciatus*
*Cecapterus pinnulatus*
*Cirrhites pinnulatus*
*Paracirrhites arcatus*
" *forsteri*
" *cinctus*
*Anampses cuvier*
" *godeffroyi*
*Hemipteronotus melanopus*
*Iniistius pavo*
" sp.
*Cirripectes variolosus*
*Petroscirtes ewaensis*
*Balistes vidua*
" *bursa*
*Balistapus aculeatus*
" *rectangulus*
*Monocanthus spilosoma*
" sp.
*Cantherines sandwichiensis*
*Cantherinus pardalis*
*Alutera scripta*
*Ostracion lentiginosus*
*Canthigaster jactator*
" *cinctus*
*Tetraodon hispidus*

# A SEX DIFFERENCE IN MORTALITY IN YOUNG COLUMBIAN BLACK-TAILED DEER[1]

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The understanding of big game populations which is necessary for successful management is based largely on a knowledge of population dynamics. The three factors which interact to constitute the dynamics of a given population are production, mortality and movement. The present paper deals with mortality in a population of Columbian black-tailed deer (*Odocoileus hemionus columbianus* [Richardson] ).

The region of study lies in the north coast ranges of California, about five miles west of the town of Lakeport, in Lake County. The cover consists of a mixture of fire-tolerant shrubs—the chaparral. The climate is Mediterranean, characterized by cool, wet winters and hot, dry summers. The average rainfall is about 28 inches, but deviations of almost fifty percent occasionally occur. Various aspects of relations of deer to vegetational cover in this area have been reported upon in previous publications (Biswell *et al.*, 1952; Taber, 1953b).

The deer with which the present study deals are resident, usually living out their lives on rather restricted ranges. Fawns are dropped in late May and early June; the bucks lose their velvet about the first of August; the rut begins in early October and most of the breeding takes place during the first two weeks of November. Does usually breed for the first time at 17 months of age but occasionally do not breed until they are 29 months old. There is no evidence of breeding of fawns during their first fall (Taber, 1953b).

Data concerning mortality rates in young deer were gathered in three ways: (1) by noting the age and sex of any deer found dead; (2) by determining the sex ratio in fawns and yearlings in winter herd composition counts and (3) by intensive studies of a deer population on about 400 acres. Carcasses were aged by dentition, pelage and season of death (with respect to known average molting and fawning dates). They were sexed by examination of the external genitalia or, if these were no longer present, by a study of the secondary sex characters of the skeleton.

Since carcasses are generally found when sex can no longer be determined from external genitalia, the study of sex characters in the skeleton is the most important source of information on sex. Secondary sex characters develop in response to the action of sex hormones, and their appearance is not synchronous in all individuals. Small swellings at the antler site may be detected on the skulls of some males at two months of age, but in others these do not appear until the fourth month.

[1] Contribution from Federal Aid in Wildlife Restoration Project California W 31 R and the Museum of Vertebrate Zoology, University of California.

This means that the presence or absence of antler swellings may not be considered diagnostic of sex in all individuals until the age of four months. Aside from skull characters, the best indicator of sex so far discovered is the shape of the pubic symphysis. Like the presence or absence of antler swellings, the distinctive male and female shapes of the pubic symphysis are reflections of sex hormone levels. Again, satisfactory sex determination is not always possible when age is less than four months. Thus there is at present no reliable method of discovering the true sex ratio in weathered fawn carcasses under four months of age by direct observation. Fawn carcasses under four months of age (in Table 1) are omitted from the calculation of the sex ratio in fawn carcasses.

TABLE 1.—139 CARCASSES OF YOUNG DEER TALLIED BY AGE AND SEX

| Age class | Males | Females | Unsexed |
|---|---|---|---|
| 0–3 months..... | 16 | 11 | 10 |
| 4–12 months..... | 46 | 33 | *16 |
| 13–19 months..... | 6 | 0 | * 1 |

* Remains too fragmentary for sexing.

In the case of carcasses of fawns four months old or older which could not be sexed because of the fragmentary nature of the remains, it is assumed that the same sex ratio prevails as is found in members of the same group which could be sexed.

Between April, 1949 and April, 1953, 139 carcasses of young deer were found. Of these 132 were fawns (0-12 months old) and 7 yearlings (13-19) months old.

The ratio between the sexes in carcasses of four months and older indicates that more males than females succumbed. Before one can say that this represents a differential mortality between the sexes, however, it is necessary to establish the proportions of the sexes at birth. A recent review of this subject, including data from deer of the present study, indicates that the sex ratio at birth is probably about 120♂♂ :: 100♀♀ (Taber, 1953a). The carcass data for fawns (Table 1) indicate a still higher proportion of males, namely 139♂♂ : : 100♀♀. When the carcass data for yearlings are included the ratio is 162♂♂ : : 100♀♀. It seems apparent that differential mortality did occur.

It is possible to check this conclusion by recourse to records of herd composition. Winter herd composition counts are taken in December and January when deer have quieted after the rut and before all bucks have dropped their antlers. It has been found practicable for an experienced observer, working from a vantage point with binoculars and telescope, to classify almost all deer seen. The classification consists of five categories: adult bucks; yearling (19-month-old) bucks; adult does; yearling does; fawns. From these counts it is possible to derive a yearling buck-doe ratio. Data from fifteen counts, taken so as to sample evenly the time and region from which carcasses were derived, are presented in Table 2.

The ratio derived from these herd composition counts is 64♂♂ : : 100♀♀. Thus, the evidence from herd composition counts strengthens the conclusion that between birth and eighteen months of age bucks suffer a higher mortality than does.

TABLE 2.—NUMBERS OF YEARLING DEER OBSERVED DURING WINTER HERD COMPOSITION COUNTS

| Count No. | Yearling Bucks | Yearling Does |
|---|---|---|
| 1 | 4 | 8 |
| 2 | 1 | 6 |
| 3 | 3 | 5 |
| 4 | 5 | 4 |
| 5 | 6 | 9 |
| 6 | 4 | 4 |
| 7 | 2 | 3 |
| 8 | 4 | 6 |
| 9 | 5 | 5 |
| 10 | 2 | 4 |
| 11 | 1 | 5 |
| 12 | 7 | 6 |
| 13 | 2 | 6 |
| 14 | 6 | 7 |
| 15 | 2 | 6 |
| Total | 54 | 84 |

In part of the area more intensively studied, further evidence of differential mortality was obtained. The fawn crop in this 400-acre area in July, 1951 was 35. Assuming a ratio of 120♂♂ : : 100♀♀, this would be 19 male to 16 female fawns. After the male fawns had grown their button antlers a fawn sex ratio count was made. Of the 14 animals surviving to this time (December) 5 were males, 6 were females, while 3 could not be classified. By June, 1952 only 9 of the original 35 fawns survived. These were in a ratio of 2♂♂ : : 7♀♀. This indicates a loss of 17 males and 9 females from the original population. Twenty-two fawn carcasses were found in this area. Of these 9 were males, 4 females, and 9 could not be classified.

The cause of this mortality is important. Unfortunately, it cannot be determined in every case. Among those for which the probable cause of death could be determined, the majority of deer died of starvation, occasionally complicated by disease.

Accidents, including rattlesnake bites, drowning, and being caught in fences, were the second most common cause of death. Predation accounted for very few deaths.

It seems pertinent to understand how young bucks and young does differ from each other, and how these differences might contribute to the observed differential mortality.

We notice that young bucks have a tendency to stray further from the mother than do young does. This is reflected in the sex-ratio of live-trapped fawns. During October and November, in 1951 and 1952, eleven fawns were trapped. Ten were bucks and one was a doe. Eight buck fawns were trapped without any accompanying adult doe; two buck and the single doe fawn were each accompanied by an adult doe when caught. This illustrates the tendency for male fawns to investigate new situations without waiting for the mother's experienced leadership. Again, during winter herd composition counts, a record was kept of whether or not yearling deer were associated with other members of a family group. Forty-nine yearling bucks and 72 yearling does were classified in this respect. Of the yearling does, 47 per cent accompanied adult does, presumably their mothers; of the yearling bucks only 16 per cent accompanied adult does. In a smaller population under intensive observation, 6 yearling males were present in 1951. Of these, only two were closely attached to family groups. The other four tended to travel independently most of the time, and in some cases could not be

related to any doe group. Even the two definitely belonging to family groups spent much more time away from the group than did yearling does in similar associations. A more pronounced antagonism of the mother toward the yearling male than toward the yearling female, during the time when fawns are young, may be in part responsible for the loose family ties of young males. The result is that young does spend a longer period learning their way around in their environment. It is plain that this might well result in a greater mortality of bucks through accidents and predation, but it is by no means obvious that the same would apply to losses through starvation.

To understand the mechanism of differential mortality through starvation, it is necessary to investigate the food-economy of young deer as it is influenced by sex hormones. It was previously stated that the deer of this study display secondary sex characters from about four months of age; the presence of these characters indicates the secretion of sex hormones. Numerous experiments on effects of male sex hormones (androgens) on metabolism of mammals show that they include increased growth of bone and muscle, reduced accumulation of fat and an accompanying rise in basal metabolism (Kenyon, Knowlton and Sandiford, 1944; Kochakian, 1946). This increased metabolism would necessarily imply a greater food requirement for males. Applied to the present data this would indicate a lessened chance for survival when food supplies are low in either quality or quantity. An example of this may be taken from the literature on sheep; a young ram must be fed about 15 per cent more total digestible nutrients than a ewe of equal age and weight (Morrison, 1948).

Another investigation of Columbian black-tailed deer is being carried out near Hopland, California, by W. M. Longhurst. From November, 1951, through April, 1952, a season of unusually heavy mortality, he found 76 fawns dead. Most of them were victims of starvation through parasitism. Of these, 52 were males and 24 were females. The following year, November, 1952, through February, 1953, a season of low mortality, he found only four male and four female fawns dead (Longhurst and Douglas 1953).

Looking farther afield, one finds that the literature on deer contains many instances of unbalanced sex ratios. These may be caused, in part, by differential sex mortality of the type described above.

Gunvalson, Erickson and Burcalow (1952) reporting on deer populations in Minnesota, point out that on good ranges the sex ratio tends to be about equal, while (p. 130), "In areas which have been protected from hunting for a long time and where the deer population has increased beyond the sustained carrying capacity and resulting in known starvation losses, (a) adult does are greatly in excess of adult bucks . . . . ."

Similarly, Cowan (1950, p. 587) states, "National parks of Canada between 1943 and 1946 supported overcapacity populations of big game in which moose, elk, mule deer and bighorn were in direct competition for a declining food supply on winter ranges. Under these conditions, sex ratios among adult animals favored females in all species except moose, although bighorn

and goats were near equality."

Mohler, Wampole and Fichter (1951) reporting on overstocked deer ranges in the Nebraska National Forest, state that pre-hunt counts showed an adult sex ratio of one buck to two does. They give detailed kill records for the first hunt, which was an intensive any-deer harvest. These figures show that while the sex ratio among fawns was nearly even (30♂♂ : : 31♀♀), the sex ratio among yearlings was heavily in favor of does (18♂♂ : : 27♀♀). This gives a ratio of 67♂♂ : : 100♀♀, a value quite similar to the 64♂♂ : : 100♀♀ found in the yearlings of our California population (from data in Table 2).

Within the supposition that poor range conditions are reflected in an unbalanced sex ratio is the implication that good range conditions should result in a balanced sex ratio. This is indeed what Gunvalson, *et al.* reported. In addition, Halloran (1943) working in the Aransas National Wildlife Refuge, Texas, found a ratio of 93♂♂ : : 100♀♀ (yearling and older deer) on range which he considered to be good.

The famous hoof and mouth disease eradication campaign in the Stanislaus National Forest, California, took place in 1924-6, at the end of a period during which deer had increased rapidly because of fortuitous range improvements. Deer were shot and poisoned indiscriminately in an effort to clear the area, and over 22,000 were actually tallied. The ratio for all age classes together was 92♂♂ : : 100♀♀ (Leopold, Riney, McCain and Tevis, 1951).

In Massachusetts, where range damage has been avoided by means of a heavy any-deer harvest for many years, a total kill of 74,887 was reported between 1910 and 1950. The sex ratio was 118♂♂ : : 100♀♀ (Shaw and McLaughlin, 1952).

These examples support the thesis that under good range conditions sex ratios tend to be about equal, or heavy in males, while under poor range conditions the reverse is true, if one leaves out the effects of selective shooting. This could be explained on the basis of a heavier mortality in young male deer where range conditions are poor then on areas where the food supply is adequate.

It must not be concluded, however, that all of the evidence points in this direction, nor that differential sex mortality in fawns is the only factor influencing adult sex ratios in unhunted herds. Thus, in the Jawbone deer herd the sex ratio in the Cherry unit, with relatively poor range conditions and poor survival of fawns was 95♂♂ : : 100♀♀ for adults and yearlings in the winter of 1949 (Leopold, *et al., op. cit.*). In the portion of our area under intensive observation differential sex mortality resulted in a sex ratio in fawns surviving to the summer, 1952, of 29♂♂ : : 100♀♀. Yet at the same time the ratio among adults and yearlings was 54♂♂ : : 100♀♀ despite the fact that only bucks are taken during the hunting season. In the preceding summer, 1951, the yearling sex ratio was 60♂♂ : : 100♀♀, and the adult sex ratio 70♂♂ : : 100♀♀. These ratios suggest a possible differential sex loss in older deer, with females succumbing more frequently. Carcasses of adult and yearling deer recovered in this area were 2♂♂ : : 11♀♀, if hunting losses are excluded.

The entire subject of differential sex

mortality among various age classes of deer is one requiring further investigation in different areas with animals subjected to differing environmental pressures before any broad conclusions can be accepted. In Lake and Mendocino Counties, California, where there is strong evidence for a proportionately heavy loss of male fawns, the protein content of the food supply declines sharply in late summer. Heavy losses through malnutrition may occur from August through October. Winter losses may be of importance, but frequently winter is a period of relatively abundant green herbaceous feed and losses are negligible. In migratory herds, to the contrary, summer and fall months are periods when food supplies are usually adequate; whereas losses from malnutrition occur in late winter and spring. The season when the population is subjected to the greatest environmental stress may be found to have a direct bearing on the type of mortality that occurs.

The normal tendency in a lightly harvested deer population is to increase to the limits of food supply. This tendency is particularly strong in populations from which only bucks are harvested, because there is no control of the production rate. Viewed in the light of data presented here we may expect a lowered survival of male fawns in populations hunted under the buck law, whereas an any-deer harvest may result in a higher proportional survival of male fawns.

## SUMMARY

In a study of black-tailed deer it has been found that there is a differential mortality among deer under eighteen months of age, appreciably more males dying than females. This is manifested in the sex ratio of carcasses (139♂♂ : : 100♀♀) and in the sex ratio of surviving yearling (19-month-old) deer in the winter herd (64♂♂ : : 100♀♀). Most mortality was connected with starvation; accidents caused a moderate number of deaths. It is suggested that the higher metabolic rate of the male, reflected in its greater activity, curiosity, independence, etc. results in an increased male mortality due to starvation, disease and accidents. Examples drawn from the literature seem to demonstrate that under poor conditions the adult sex ratio tends to be heavier in females, while under good range conditions the sex ratio tends to be about equal. The possibility is suggested, however, that the adult sex ratio may be influenced in the opposite direction by a heavier differential loss among adult females. It is pointed out that the type of differential sex loss which occurs may be affected by the season at which the population is subjected to the most severe environmental stress.

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# THE EFFECT OF LEAD POISONING ON THE FERTILITY AND FECUNDITY OF DOMESTIC MALLARD DUCKS[1]

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Most of the lead shot fired by hunters in pursuit of waterfowl falls over water, sinks to the bottom, and thus remains more or less permanently available to bottom-feeding birds. That these shot are eaten as food or grit by many species of birds—ducks, geese, swans, coots, and rails—with fatal results has been pointed out by many investigators during the past half-century (Grinnell, 1894; Bowles, 1908; McAtee, 1908; Wetmore 1915, 1918, 1919; Van Tyne, 1929; Magath, 1931; Howard, 1934; Wilson, 1937; Shillinger and Cottam, 1937; Jones, 1939; Osmer, 1940.)

Although mortality from lead poisoning is very apparent and widespread, its significance has been difficult to measure quantitatively. When wintering ducks die from lead poisoning their bodies are prominent around water holes in the ice. Such mortality is easily recognized and often receives widespread comment in newspapers. That this same mortality occurs constantly when water is open and cover available for

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, the Wildlife Management Institute, the Missouri Conservation Commission, the Edward K. Love Foundation, and the University of Missouri cooperating.

poisoned birds to hide until overtaken by death or a predator, goes unnoticed and cannot be accurately measured.

Recently (Elder, 1950) it has been shown by means of the fluoroscope that on one breeding marsh up to 24 per cent of juvenile ducks of some species on the area sustained lead poisoning by the time of their capture for banding. An additional segment of the population must pick up shot during each week of summer. Our experiments at the Delta Waterfowl Research Station have proven juvenile ducks much more resistant to the effects of ingested lead than are adults of the same species. This suggests that large numbers of ducks may receive sub-lethal doses of lead, and later show no outward evidence of previous poisoning.

The long-lasting results of sub-acute lead poisoning in man have been pointed out by Lanza (1935). Such doses of lead suffered by either human parent cause pregnancy to end in abortion or stillbirth (Aub, *et. al.* 1926). The toxic effects of lead on germ cells of male chickens and rabbits have been described by Cole and Bachhuber (1914), and Cole (1915) and of guinea-pigs by Weller (1915). Magath (1931) and Shillinger and Cottam (1937) have suggested that ducks surviving lead poisoning might be sterile. If the ingestion of shot by juvenile ducks proved to be widespread and to have a deleterious effect on fecundity or fertility of the birds after they became adult, we should have increased cause for concern about the future of our waterfowl populations.

The problem of male fertility following ingestion of lead shot was investigated by Cheatum and Benson (1945), who concluded that no ill effects had resulted from their regimen of poisoning. Their experimental drakes had been treated with only one shot at a time over a period of several months. No measures of degree of toxemia—such as weight loss or anemia—were reported. Only 183 eggs from the 24 hens mated to leaded drakes and only 161 eggs from the controls were available.

We, therefore, decided to test further the results of lead poisoning in both drake and hen mallards.

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### THE 1948 EXPERIMENTS

STOCK: The birds were of a good quality, small, trim, domestic mallard stock; they were practically free of white spotting and had been suffused with wild stock in recent years. The

birds were wing-clipped, and leg banded for individual identification.

LEADING: Ducks to be experimentally leaded were kept on the same diet as controls—Purina duck pellets plus whatever grass, clover, and weeds they could obtain by grazing. Number six shot obtained from shotgun shells was administered by placing the desired number of shot in a small gelatin capsule which was dropped in the back of a duck's mouth and pushed into the proventriculus by means of a moistened pencil.

EXPERIMENT I: Six shot were administered on March 15 and all birds were weighed. Fluoroscopic examination on the following day revealed that all shots fed were lodged in the gizzard. A second fluoroscopic examination was made two weeks later and half of the birds found shot-free. The others had only traces of lead or showed from one to four highly eroded, very small shot. Egg collection for this experiment extended from March 26 to April 20. After this, sexes were separated for the next experiment, so that no sperm from previous matings would remain alive in the reproductive tracts of the females when egg collection was resumed. Sperm have remained viable up to 35 days in chicken oviducts (Philips, 1917; Martin and Anderson, 1918; Nalbandov and Card, 1943).

EXPERIMENT II: To measure the effects of more severe doses of lead, the same birds were given, on April 26, a dose of 18 No. 6 chilled shot. A sample of 5 of these birds was selected at random and their weight and red blood cell counts followed to determine the degree of toxemia. The birds showed an average body weight loss of only two ounces and a decline in red cell count of only 12.6 percent (from 3.56 million to 3.11 million RBC per cubic millimeter). Egg collection following this dosage was resumed May 31, three days after the sexes had again been put together, and was continued until July 2. The delay of 3 days before egg collection was begun was to preclude collection of eggs fertilized by stale sperm accumulated by the males during their period of isolation. The inferiority of such sperm has been shown by Fronda (1926), and Nalbandov and Card (1943).

PROCEDURE: During each of the egg collection periods the ducks were separated into four groups, each with 12 hens and 4 drakes, made up as follows:

Group I. Both sexes were survivors of lead poisoning.

Group II. Females alone were survivors of lead poisoning, males were normal, unleaded drakes.

Group III. Females normal, males were survivors of lead poisoning.

Group IV. Controls: males and females normal.

The eggs were gathered daily, marked as to date and group, and stored at about 55° F. for 14 days before being placed in the incubator. All eggs were candled on the fourth and twenty-fourth days after incubation was begun. Abnormal eggs were opened to determine the number infertile, the number of early embryonic deaths, and the number that died after blood was established in the embryo.

The work of Nalbandov and Card (1943), Munro and Kosin (1945) and Gowe (1950) has made clear that fertility of eggs showing no develop-

ment when candled on the fourth day of incubation cannot be determined without careful examination of the germinal disc. This procedure was followed with all duck eggs and the infertile eggs thus separated from those having suffered early embryonic mortality. Without this precaution it would be quite impossible to know whether failure to develop was actually the result of male sterility or of a lethal factor from the female causing anomalous development and early embryonic death. According to Gowe's work there is still a residual error of 3.7 per cent which cannot be resolved without fixing, staining, and sectioning of each germinal disc for microscopic examination.

RESULTS: Macroscopic examination of the germinal discs of the eggs candled out after four days of incubation provided the data presented in Table 1.

Statistical analysis revealed a probable difference between groups in Experiment I but not in Experiment II. Failure to demonstrate a difference between groups in the second experiment was perhaps due to the variability within groups resulting from individual hen differences. However, in the second experiment (following ingestion of 18 shot) the percentage of infertile eggs found in Group I, where both sexes suffered from lead poisoning, was twice as great as among the controls; this suggests that a larger number of birds on this heavy dose of lead might have revealed a statistically significant difference. This is further suggested by the finding that the percentage of eggs found infertile following the 18 shot was significantly greater than that following dosage with 6 shot.

It should be pointed out that the leaded birds did not suffer as severely from the dose of 18 shot as do many birds surviving lead poisoning in the wild. This was indicated by the fact that neither decline in weight nor decline in number of red blood cells was significant. It was concluded that the experiment should be repeated another year with mallards surviving a more severe bout of lead poisoning.

Previous work completed at the Delta Waterfowl Research Station showed that ducks suffering from lead poisoning lost at least 25 percent of body weight before dying. The fact that mallards in the present experiment did not show severe symptoms following doses of lead shot found lethal to adult mallards at Delta in 1947 was undoubtedly due to a combination of the following factors:

1. Delta birds were primarily grain-fed while ducks in the present experiment were fed pelleted laying mash—

TABLE 1.—EFFECT OF LEAD POISONING ON THE FERTILITY OF MALLARD DUCK EGGS, 1948

| Group | Experiment I | | Experiment II | |
|---|---|---|---|---|
| | No. of Eggs Set | Percent Infertile | No. of Eggs Set | Percent Infertile |
| I — Males and Females Leaded | 220 | 5.4 | 223 | 12.1 |
| II — Females Leaded | 196 | 1.0 | 270 | 8.5 |
| III — Males Leaded | 126 | 3.1 | 205 | 8.3 |
| IV — Controls | 250 | 3.6 | 257 | 6.2 |

a much more complete and nutritious diet.

2. Wild mallards used at Delta were more susceptible to the effects of lead poisoning than were the domestic strain of mallards used in the present study. This agrees with the findings of Jordon and Bellrose (1950).

3. Ducks may be more resistant to lead poisoning during spring than they are in late summer (following their molt) when the previous tests were made at Delta.

### THE 1949 EXPERIMENTS

STOCK: Incubation tests during the previous year provided 394 ducklings, 97 per cent of which were reared successfully. This supply was used for the 1949 experiments; thus the ducks were of uniform age and from the same stock as in the previous year.

LEADING: This was accomplished in the same manner as in the preceding year but was begun earlier, 18 No. 6 chilled shot being administered February 28 while the ducks were still being fed on their winter grain diet of corn and wheat. This dose of 18 shot induced greater toxic effects than in 1948 when the birds were leaded while on a mash diet. The mortality was so great that a second group had to be leaded with the same dose March 16 in order to secure sufficient survivors for the experiment. In 1948 the dose of 18 shot caused no mortality while in 1949 the same dose caused the death of 30 of the 49 hens and 20 of the 27 drakes. The degree of toxemia was followed in all birds by means of body weight records and red cell counts. It may be seen from examination of Tables 2 and 3 that the surviving ducks suffered very significant loss in body weight and severe anemia within five days after being leaded. It is clear that the birds used in the 1949 experiments had suffered much more severely from lead poisoning than had the birds used in the previous year's experiments.

PROCEDURE: The birds were paired in four groups as in the preceding year with 9 or 10 hens in each group.

TABLE 2.—BODY WEIGHT OF MALLARDS SURVIVING LEADING AND USED FOR THE BREEDING COLONY, 1949

| | Females | | | Males | | |
|---|---|---|---|---|---|---|
| Date Leaded | No. | Aver. Wt. Lbs. Oz. | Loss in 5 Days | No. | Aver. Wt. Lbs. Oz. | Loss in 5 Days |
| Feb. 28..... | 9 | 2:7 | 18% | 3 | 2:10 | 21% |
| Mar. 16..... | 10 | 2:12 | 9% | 4 | 3:0 | 13% |

TABLE 3.—ANEMIA SUFFERED BY MALLARDS SURVIVING LEADING, 1949

| | Females | | | Males | | |
|---|---|---|---|---|---|---|
| Date Leaded | No. | RBC/mm³ | Loss in 5 Days | No. | RBC/mm³ | Loss in 5 Days |
| Feb. 28..... | 5 | 3.29 million | 62% | 3 | 3.18 million | 47% |
| Mar. 16..... | 10 | 3.25 million | 37% | 4 | 3.25 million | 41% |

In order to follow the egg production and fertility record of individual hens, each was provided with a separate run, 4′ by 16′, with constant access to water and food. Three drakes were provided for each of the four groups, this a male served three or four hens, being moved each day to another member of his harem.

Eggs were gathered daily, marked as to date and hen number, and stored at 55° F. They were turned daily for 7 days, then taken to the incubator; hence a new setting was started every week from April 4 until early June—a total of 10 settings. All eggs were candled on the 4th and 24th days after incubation was begun, and the abnormal eggs removed at this time, opened to determine number infertile, number of early embryonic deaths, number that died after blood was established in the embryo, and the number that died later in development but before hatching began.

RESULTS: Table 4 presents the results of these incubation tests. From examination of these data it may be seen that there were no dramatic results of lead poisoning on either sex alone or when mated survivors were compared with controls. Chi-square tests showed no case in which survivors of severe lead poisoning were inferior to normal birds in fertility, in percentage of early embryonic deaths or when all these early factors were considered cumulatively. However, Groups II and III, in which males and females respectively were survivors of lead poisoning, did show a significantly greater percentage of late embryonic deaths (5 - 24 days of incubation) than did controls. The very low hatching success in all groups was probably due to the use of forced-draft incubators for it has been shown that the old still-air machine used at the Delta Research Station is much superior for duck eggs, giving hatching rates from 70 to 80 percent. This poor hatching success for all groups may have masked the effects of lead poisoning.

An examination of Table 5 reveals that the 1948 egg collection period which came at the end of the laying season (June and July) showed a progressive decline in fecundity during each week, while in 1949 the collection period came earlier (April and May) and no progressive decline in fecundity was found. This explains why the average egg production for both normal and leaded groups in 1949 exceeded those for 1948.

TABLE 4.—EFFECT OF LEAD POISONING ON FERTILITY AND EMBRYONIC DEVELOPMENT OF MALLARD DUCK EGGS, 1949

| Group | Data From All Ten Settings | | | | Data From First Seven Settings | | |
|---|---|---|---|---|---|---|---|
| | Number of Eggs Set | Per cent Eggs Infertile | Per cent Early Embryonic Deaths | Per cent Deaths After Blood Formed | Number of Live Eggs Fifth day | Per cent Deaths 5–24 Days | Per cent Died at Hatching |
| I | 394 | 5.8 | 4.1 | 1.8 | 306 | 20.9 | 32.4 |
| II | 375 | 2.4 | 1.1** | 2.4 | 308 | 26.6** | 31.5 |
| III | 449 | 6.0 | 1.1** | 0.9 | 356 | 22.5* | 35.4 |
| IV | 426 | 3.8 | 4.9 | 1.6 | 362 | 15.5 | 32.3 |

* Significant at the 5 per cent level of confidence.
** Significant at the one per cent level of confidence.

TABLE 5.—COMPARATIVE FECUNDITY OF POISONED AND NORMAL DUCKS STARTING 5 WEEKS AFTER LEADING

| | 1948—(June–July) | | | | 1949—(April–May) | | | |
|---|---|---|---|---|---|---|---|---|
| | (25 ♀♀) Leaded | | (23 ♀♀) Normal | | (17 ♀♀) Leaded | | (17 ♀♀) Normal | |
| Week | No. of Eggs | Aver. per ♀ | No. of Eggs | Aver. per ♀ | No. of Eggs | Aver. per ♀ | No. of Eggs | Aver. per ♀ |
| 1..... | 127 | 5.08 | 140 | 6.09 | 77 | 4.53 | 83 | 4.88 |
| 2..... | 118 | 4.72 | 130 | 5.65 | 76 | 4.47 | 92 | 5.41 |
| 3..... | 83 | 3.32 | 94 | 4.09 | 82 | 4.82 | 78 | 4.59 |
| 4..... | 76 | 3.04 | 103 | 4.48 | 101 | 5.94 | 94 | 5.53 |
| 5..... | 69 | 2.76 | 89 | 3.87 | 96 | 5.65 | 84 | 4.94 |
| 6..... | 44 | 1.76 | 58 | 2.52 | 86 | 5.06 | 79 | 4.65 |
| Total..... | 517 | 20.64 | 614 | 26.69 | 518 | 30.47 | 510 | 30.00 |

In the first year the average number of eggs laid by normal hens during this 6-week period was significantly greater than the average number laid by leaded hens (26.7 *vs.* 20.7). This difference, however, may not be attributed to any specific or residual effect of lead poisoning for no such difference was obtained in 1949 when the leading had been achieved earlier in the spring. However, if we compare the average egg production per hen for the entire season we find that in 1948 normal hens surpassed leaded ones by 17 eggs (67 *vs.* 50) and in 1949 they exceeded leaded hens by 8 eggs (50 *vs.* 42). If we compare the April-May period alone for the two years we find that the normals exceeded leaded hens by 11 eggs in 1948 and 7 eggs in 1949. Hence we may conclude that lead poisoning during late winter or early spring may have a real effect on fecundity during that laying season. Whether or not this effect is great enough actually to reduce productivity of wild female ducks is still problematical.

From the 1949 work it is apparent that very severe toxemia following high-level dosage with ingested lead shot does not decrease fertility or increase early embryonic mortality in domestic mallards. The possibility that lead poisoning in wild mallards, especially if suffered in late summer of their first year while sexually immature, might have an effect on fertility or embryonic development, suggested the need for one further year of experimentation. Consequently, juvenile mallards were reared at the Delta Waterfowl Research Station in the summer of 1950 from eggs gathered in the wild. These ducklings were leaded at 4 to 8 weeks of age and the degree of toxemia followed as before. These birds were transported to the University of Missouri and were confined the following spring as pairs in the same 4′ x 16′ runs used the preceding year. This attempt met with complete failure for no eggs were layed under the conditions provided. Therefore, the effects of lead shot ingested by juvenile ducks, as so frequently found among redheads at Delta, remains an enigma.

SUMMARY

The deleterious effects of ingested lead on the germ cells of chickens, guinea-pigs, rabbits and man suggested the need for discovering whether similar effects are suffered by waterfowl recovering from poisoning as a result of eating lead shot.

To determine this, small, trim domestic mallards were treated with No. 6 chilled shot in gelatin capsules; the fate of the shot followed by means of a fluoroscope; the degree of toxemia induced measured by following body weight loss and red blood cell counts.

Survivors were used in setting up four breeding groups: (1) both sexes leaded, (2) females only leaded, (3) males only leaded, and (4) controls. Eggs gathered were uniformly stored, incubated, candled on the 4th and 24th days, and those removed were broken for examination to determine fertility, or cause of death.

In the first year the birds received six shot March 15, and 18 shot April 26. Because of the rich, soft diet the birds showed only mild symptoms of lead poisoning. There was no statistically significant difference in fertility or embryonic deaths among the four breeding groups but the percent of infertile eggs in Group 1, where both sexes had been leaded, was greater following 18 shot than it was following ingestion of 6 shot.

In the second year each female was housed in a separate run. Thus the fecundity and fertility of each was followed individually and the variability among them measured. Leaded birds received 18 shot while on a grain diet, and the resulting toxemia was very severe. However, normal birds did not exceed leaded birds in fertility, embryonic success, or hatchability. But in both years the normal hens surpassed leaded hens in fecundity for the season.

Because hand-reared, wild stock failed to lay in captivity the residual effects of lead poisoning suffered by juvenile birds during their first summer remains unknown.

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# LIFE HISTORY AND MANAGEMENT OF THE AMERICAN GRAYLING (*Thymallus signifer tricolor*) IN MONTANA[1]

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## Introduction

The American grayling, *Thymallus signifer tricolor*, was once abundant in Michigan and Montana—the only areas native to this species in the United States. It has become extinct in Michigan and has progressively declined in Montana (Brown 1943) until this fish now occupies only a small fraction of its original range, which, according to Henshall (1906), was the Missouri River and its tributaries above the Great Falls. Grayling have disappeared from the Missouri River and its tributary, the Gallatin River. It is rare in the Madison River drainage and has disappeared in the main stem of the Jefferson River. Two small remnants remain in its tributaries: one in the Big Hole River drainage where it is maintained largely through artificial propagation and the other in the Red Rock Lakes area of the Beaverhead River drainage. This latter area was selected for study of grayling management because it has changed less from original conditions than other areas. Grayling, while greatly reduced in numbers, have maintained themselves here without artificial propagation. A considerable portion of this area lies within the Red Rock Lakes National Waterfowl Refuge where more complete management is possible than on private lands. Investigations were carried out in the summers of 1951 and 1952. The objectives were to develop a management plan to preserve grayling in at least one area of its original range in Montana, and to determine practices which might be applied in other areas of the state.

The Red Rock Lakes and tributaries are located in the Centennial Valley approximately 40 miles west of Yellowstone National Park. This valley, about 50 miles long and 8 miles wide, is bordered on the south by the Centennial Mountains, which form the Continental Divide, and on the north by the Gravelly and Snowcrest Ranges. The south slopes and open valley are grassland and sagebrush, with willows along most of the creeks. The north slopes support heavy stands of spruce and fir. Much of the land is privately owned and used for grazing. The Red Rock Lakes National Waterfowl Refuge, established for protection and management of the trumpeter swan, administers approximately 40,000 acres, half of which is lake and marsh. Elevation at the source of Hell Roaring Creek, the most remote headwaters of the Missouri River, is approximately 9,000 feet. The Red Rock River leaves the valley at about 6,450 feet.

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FIG. 1. Map of the upper Centennial Valley showing the locations of gill net stations, inventory sections, and irrigation ditches.

Red Rock and Elk Springs Creeks are the principle tributaries to Upper Red Rock Lake (Fig. 1) and Odell Creek is the main tributary to Lower Red Rock Lake. In addition there are many small spring-fed tributaries to these lakes. Some are permanently diverted for irrigation, and in others the channels have been greatly altered by beaver dams. Beaver dams were most abundant in the tributaries of Upper Red Rock Lake. In Red Rock Creek, which is the largest of the tributaries (Table 1), the highest temperature recorded during the summer of 1952 was 65° F. The greatest monthly fluctuation (24° F.)

TABLE 1.—CHARACTERISTICS OF MAIN CREEKS AND TRIBUTARIES IN UPPER CENTENNIAL VALLEY. VELOCITY EXPRESSED IN FEET PER SECOND AND VOLUME IN CUBIC FEET PER SECOND

| | | September average near mouth | | | |
|---|---|---|---|---|---|
| Main Creek Tributaries | Average gradient (feet per mile) | Width (feet) | Velocity | Volume | Dissolved solids ppm |
| Red Rock | 26 | 31 | 1.7 | 46 | 129.96 |
| Antelope | 150 | 4 | | | |
| Corral | 386 | 10 | | | |
| Hell Roaring | 280 | 11 | | | |
| Elk Springs | 9 | 15 | 1.8 | 20 | 124.83 |
| Picnic | 7 | 10 | | | |
| Odell | 108 | 30 | 1.0 | 17 | 78.66 |

occurred in September with a maximum of 62° F. and a minimum of 38° F. On September 20 there were 7.2 p.p.m. dissolved oxygen (70 per cent saturation) and pH was 7.8 at Section 2 (Fig. 1). Bottom materials in most of the creeks consist of boulders and rubble in the canyons, coarse to fine gravel in the upper valley, and sand and silt near the lakes and in the lower valley.

Upper Red Rock Lake has an area of 2,206 acres and a maximum depth of about six feet. Temperatures were usually uniform at all depths and the highest surface temperature recorded was 76° F. On September 20, total dissolved solids were 116.28 p.p.m. Lower Red Rock Lake has approximately 1,126 surface acres and a maximum depth of about three and one-half feet. On September 22 the total dissolved solids were 88.92 p.p.m. Swan Lake has an area of 323 acres and a maximum depth of about two and one-half feet. All three lakes have uniform basins with aquatic vegetation throughout. The lake bottoms are all composed of peat except for a small area of marl along the south shore of Upper Red Rock Lake. Shore lines are hard to define due to extensive marsh surrounding the lakes. The only exception is the south and east shore of Upper Red Rock Lake where willows, aspen, and conifers occur. Elk Lake is located in a depression at the head of Elk Springs Creek. It comprises approximately 235 acres with precipitous shores. No soundings were made but it is known to be deeper than other lakes in the valley.

The Red Rock River drains the Red Rock Lakes and meanders westerly through 12 miles of the lower valley where it empties into the Lima Reservoir. Water from the reservoir leaves the valley via outlet to the Beaverhead River.

Eastern brook trout (*Salvelinus fontinalis*) are numerous and inhabit many of the creeks and ponds in the study area. Rainbow trout (*Salmo gairdnerii*) are present only in Elk Springs Creek Drainage (including Widows Pond and Elk Lake), and Shambow Pond, an artificial impoundment near the southwest shore of Upper Red Rock Lake. Cutthroat trout (*Salmo clarkii lewisi*) are common in the headwaters of the larger creeks, but were rarely observed in the valley streams. Lake trout (*Cristivomer namaycush*) are restricted to Elk Lake. Mountain whitefish (*Prosopium williamsoni*) are common in Red Rock Creek. The white sucker (*Catostomus commersonii suckli*) and longnose sucker (*Catostomus catostomus*) are abundant in the lakes and in Red Rock and Odell Creeks. Burbot (*Lota lota maculosa*) are present in the lakes and ponds, and lower portions of the creeks. Longnose dace (*Rhinichthys cataractae*) are locally abundant in spring fed creeks, and considerable numbers of freshwater sculpins (*Cottus* sp.) are also present.

Grayling is native to practically all of the lakes and creeks. However, most of the grayling in the waters of the Centennial Valley occur in the Upper Red Rock Lake and Red Rock Creek. Brower (1896) in describing the Centennial Valley wrote, "the waters supply the anglers with superb fishing, mountain trout and grayling being abundant." Henshall (1907) reported that during the spawning season, Elk Springs Creek was "fairly alive with

grayling" in the vicinity of the U. S. Bureau of Fisheries Station. Streams reported to have them the year around were Red Rock, Hell Roaring, Corral, Picnic, Elk Springs, and Odell Creeks, as well as the Red Rock River. Many of the small spring-fed tributaries harbored grayling during the spawning season. They were caught in the Lima Reservoir for several years after construction of the dam.

About 1900 rainbow trout and eastern brook trout were introduced into this area. As late as 1915 grayling and native cutthroat trout were reported abundant in certain areas in the valley. Since the introduction of the eastern brook trout and rainbow trout there has been a decline of native species.

Beaver became abundant soon after 1935 when they were protected by a state law and establishment of the federal waterfowl refuge. Numerous beaver dams blocked grayling in the lakes from much of their spawning areas. Some of the creeks were converted to marshes by continuous series of beaver dams.

Red Rock Creek remained partially open because spring runoff was sufficient to open some of the dams. However, at least twice in the last 12 years spawning runs of grayling were stopped by large beaver dams near the lake, and when high water receded in late spring, many grayling were stranded in meadows along the creek.

Irrigation was practiced in this area before 1896 (Brower 1896), and with increased settlement in the valley more and more water was diverted for irrigation. Many spawned-out grayling returning to the lakes were lost in irrigation ditches which originated from Red Rock and Odell Creeks. Water in many of the small creeks was permanently diverted into hay meadows and grazing land, and reached the lakes and river only through seepage. Brower reported a total of 48 creeks in the valley. Although he said nothing of their accessibility to fish, his photographs and the abandoned creek-beds show that most of the small tributaries had well defined channels either to the lakes or to Red Rock River.

In 1951, as a result of beaver dams and irrigation practices, only portions of five tributaries were accessible to spawning grayling from the Red Rock Lakes and Red Rock River. Battle Creek and part of Red Rock Creek were the only tributaries used to any extent in the Upper Red Rock Lake drainage. Before the spawning season (May) of 1952 all of Red Rock Creek and its tributaries were opened by the removal of 25 beaver dams and one-fourth of Tom Creek was opened by removal of 59 such structures. Grayling spawned successfully in these newly opened areas.

The abundance and distribution of grayling in the lakes was determined by gill netting, poisoning, and angling. Over-night sets of graded, 125-foot experimental gill nets were made in Lower Red Rock Lake and Lima Reservoir. Day-sets were made in Upper Red Rock Lake and these were checked at frequent intervals to prevent grayling mortality. The total number of fish caught was recorded. The grayling caught were weighed, measured, fin clipped, scale sample taken, and released. The two species of suckers taken were not separated. Results are expressed in terms of net hours. It is believed that burbot were not taken in

proportion to their abundance.

No grayling were taken in the Lima Reservoir, and only three were caught in Lower Red Rock Lake. A fair number of grayling are still present in Upper Red Rock Lake (Table 2). In the waters sampled with gill nets, eastern brook trout were limited to Upper Red Rock Lake, in the immediate vicinity of the mouth of Red Rock Creek. One rainbow trout was caught in Lima Reservoir. A small number of burbot were caught in all of the waters sampled with gill nets. Suckers were the most abundant fish in the lakes and reservoir sampled. No nets were set in Elk Lake but grayling have not been reported since about 1930. Eastern brook trout, lake trout, and rainbow trout were found in fishermen's creels. One cutthroat trout was captured near the mouth of a small creek in Lower Red Rock Lake. Only suckers and burbot were recovered from poisoning selected areas in Swan Lake.

Grayling were most abundant in the lower portion of Red Rock Creek during the spawning season of 1951, but none was found in the upper portion.

TABLE 2.—NUMBERS OF FISH TAKEN IN EXPERIMENTAL GILL NETS IN THE RED ROCK LAKES AND LIMA RESERVOIR

| | Grayling | Eastern brook trout | Rainbow trout | Burbot | Suckers | Total |
|---|---|---|---|---|---|---|
| Lima Reservoir (1951—493½ net hours) | | | | | | |
| Number | 0 | 0 | 1 | 1 | 972 | 974 |
| Per cent of total | | | trace | trace | 99.8 | |
| Per cent occurrence | | | 4.2 | 4.2 | 100.0 | |
| Catch per hour | | | trace | trace | 2.0 | |
| Lower Red Rock Lake (1951—306½ net hours) | | | | | | |
| Number | 3 | 0 | 0 | 3 | 615 | 621 |
| Per cent of total | 0.5 | | | 0.5 | 99.0 | |
| Per cent occurrence | 8.3 | | | 8.3 | 70.8 | |
| Catch per hour | trace | | | trace | 2.0 | |
| Upper Red Rock Lake (1951—131½ net hours) | | | | | | |
| Number | 233 | 10 | 0 | 6 | 377 | 626 |
| Per cent of total | 37.2 | 1.6 | | 1.0 | 60.2 | |
| Per cent occurrence | 81.8 | 27.3 | | 13.6 | 77.3 | |
| Catch per hour | 1.8 | trace | | trace | 2.9 | |
| Upper Red Rock Lake (1952—46 net hours) | | | | | | |
| Number | 104 | 0 | 0 | 1 | 72 | 177 |
| Per cent of total | 58.8 | | | 0.6 | 40.7 | |
| Per cent occurrence | 80.0 | | | trace | 50.0 | |
| Catch per hour | 2.3 | | | trace | 1.6 | |

In 1952, after beaver dam removal, grayling were found throughout Red Rock Creek and in the lower reaches of Hell Roaring, Corral, and Antelope Creeks. They were most abundant in Red Rock Creek in May and June (spawning) and gradually decreased during the summer. The average numbers captured with an electric shocker in 600 feet of stream are as follows: 5.3(June 28 - July 1), 2.0(Aug. 12-14), 0.5(Sept. 15-17). In September, 66 per cent of the grayling were young of the year. Eastern brook trout, suckers, and freshwater sculpin were numerous. Whitefish and burbot were found only in the lower portion of the creek.

Grayling were less abundant in other tributaries of the Red Rock Lakes. Only one was observed in Elk Springs Creek but rainbow and eastern brook trout were numerous.

Spawning grayling were observed in Battle Creek in 1951 and 1952, but no grayling fry were found. The bottom materials in Battle Creek were mainly detritus and peat and were probably not suitable for successful grayling reproduction. Grayling were in Tom Creek during the spawning season (the part opened by beaver dam removal) but disappeared soon afterwards. Fry were abundant in this stream in July. In September occasional schools of fingerlings were observed. Grayling were the only species of fish observed in Tom Creek. Some grayling fry were found in Odell Creek in July. Eastern brook trout, cutthroat trout, and suckers were the only species captured in August (electric shocker and rotenone).

The kinds of fish present in the small creeks and Red Rock River in the lower Centennial Valley were determined by poisoning during September 1952. Grayling were found in only three creeks. The average numbers of grayling recovered in 600 feet of stream were: 2(West Creek), 3(Metzel Creek), 7(Long Creek). All were young of the year (3.4 - 5.1 in. total length). Burbot, suckers, and freshwater sculpin were also found. Cutthroat trout were found in Long Creek only. Metzel and Long Creeks are tributaries to the Red Rock River and West Creek to the Lima Reservoir. These are the only creeks known to be accessible to fish from the river and reservoir.

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## OBSERVATIONS ON LIFE HISTORY

Information on the movements of grayling was obtained by marking (fin removal) and subsequent recovery.

A total of 370 were marked as follows: 289(Upper Red Rock Lake), 56(Red Rock Creek), and 25(Antelope Creek). Recovery of 14 was accomplished by gill netting, shocking, and angling. Since the same mark was used more than once for a collection at a given station, the exact dates of marking could not be determined from recovered fish. If recovered fish showed movement, the distance traveled was determined by map measurements.

Two grayling were recovered which showed movement during the spawning season. One marked in Upper Red Rock Lake (Fig. 1, Sta. 1) during the summer of 1951 was recovered in Hell Roaring Creek by angling, July 5, 1952. The total distance traveled was 11.7 miles (upstream). Hell Roaring Creek was not accessible until May 1952, due to the presence of impassable beaver dams. The other grayling was marked in Antelope Creek between May 24-30, 1952. This fish was found dead in an irrigation ditch on June 12, 1952, 4.4 miles down Antelope and Red Rock Creeks, and 0.6 mile down the irrigation ditch from the point where marked. This fish was probably attempting to return to the lake.

One grayling marked at Station 1, in the Upper Red Rock Lake sometime between July 27 - August 7, 1952, was recovered at Section 1, in Red Rock Creek August 12, 1952 (electric shocker). This fish traveled upstream a distance of 3.4 miles.

A total of 11 marked fish were recovered during the summer of 1951-1952 in Upper Red Rock Lake. Ten of these were recovered at the same station where marked, and seven of these ten were recovered within a few hours after having been marked and released. One grayling marked at Station 1 was recovered at Station 3, a distance of 0.9 mile (Fig. 1).

The exact time the spawning run began in Red Rock Creek was not definitely established. A run was evident in the second week of May 1952, after all ice had disappeared from the lakes. Brown (1938) found the grayling spawning period varied greatly between years, and between different localities in the same year. He reported that the spawning run usually began the day after the ice went off at Grebe Lake, Yellowstone National Park. Here spawning occurred between May 15 and June 20 during the five years previous to 1937. In 1936 at Lower Odell Creek, tributary to the Madison River, Montana, Brown reported the first grayling entered the fish traps on March 15. The peak of the run was April 16, and the last grayling appeared April 24. Gustafson (1948) found that the European grayling (*Thymallus thymallus*) began the spawning run before the ice went off.

Spawning activity was first observed May 19, 1952 in Red Rock Creek. At this time one partially spent female was caught with four others that were still "green." Spawning activity was observed in this creek until June 6. The spawning run in Antelope Creek was more concentrated. It occurred between May 23 and June 1. Water temperatures were generally 5-10 degrees higher in Antelope Creek than in Red Rock Creek.

Grayling were observed to be most abundant in the middle third of Red Rock Creek during spawning. They were also numerous in Antelope Creek. A few were found in Lower Red Rock

Creek but turbidity made observations difficult here.

Bottom samples were taken in all spawning areas in order to determine the abundance of grayling eggs in relation to the bottom materials and location. Approximately 50 square-foot bottom samples were taken for the egg counts in or adjacent to each of the inventory sections in Red Rock Creek, and in the lower portion of Hell Roaring and Antelope Creeks (Fig. 1). Bottom materials were classified (Roelofs 1944) on the basis of 20 square-foot samples from the same areas where eggs were taken. Grayling eggs could not be located in bottom materials that were composed of sand and silt. Some eggs were found in pools, but those were always below riffles used by spawning grayling and were probably washed down from the riffle. Grayling were not observed spawning in pools. Since observations showed no grayling eggs in bottoms composed of sand and silt, all quantitative samples were confined to riffles where the bottoms were composed mainly of gravel or rubble (Table 3). Most of Antelope Creek is composed of riffles, and grayling eggs were found in practically every area sampled. About 60 per cent of Red Rock Creek is riffle area. Here the eggs were concentrated on the lower end of the riffle, i.e., the area of transition between a pool and a riffle.

Recently hatched grayling fry were found in bottom materials collected (June 2-7) in Antelope Creek and in Sections 1 and 2 of Red Rock Creek. No hatching was observed in other sections of Red Rock Creek at this time. Grayling fry were observed on the surface of the water on June 12. The yolk sac had been absorbed in most of these. The period between fertilization and hatching was estimated to be 14-19 days in 1952. This information agrees with that of Brown (1938) who found a variation of 11-22 days depending upon the water temperatures and other factors. Water temperatures in Red Rock Creek varied from 38-61° F. during the incubation period.

Fry were numerous for two to three weeks after hatching in back waters and protected areas along the creek, away from strong currents. During this time they were relatively helpless and made little attempt to hide when disturbed. The abundance of grayling fry was estimated in these areas at two different times by means of quantitative samples. A total of 160 samples from eight stations were taken each year in Red Rock Creek. Results are given as

TABLE 3.—AVERAGE NUMBER OF GRAYLING EGGS PER SQUARE FOOT AND THE PERCENTAGE COMPOSITION OF EACH TYPE OF BOTTOM MATERIAL PRESENT

| Creek and section | Eggs/ sq. ft. | Coarse rubble | Fine rubble | Coarse gravel | Fine gravel | Sand |
|---|---|---|---|---|---|---|
| Red Rock Creek | | | | | | |
| Section 1 | 0.3 | .. | .. | .. | 70 | 30 |
| Section 2 | 57.8 | 13 | 20 | 31 | 29 | 7 |
| Section 3 | 6.5 | .. | 6 | 35 | 50 | 8 |
| Antelope Creek | 43.0 | .. | .. | 43 | 52 | 5 |
| Hell Roaring Creek | trace | 51 | 20 | 17 | 9 | trace |

number of fry per cubic foot of water. In 1951, the average was 3.1 fry (June 17-19). Their numbers decreased to 0.6 fry (June 26 - July 1). In both sampling periods fry were most abundant between Sections 1 and 2 (Fig. 1), where there were 11.6 and 1.7 respectively. None was found in the tributaries to Red Rock Creek at this time. All of Red Rock Creek and its tributaries were accessible in 1952. The average number of fry per cubic foot for Red Rock Creek was 1.1 on June 17-19, and 0.8 on June 26 - July 3. Fry were most numerous between Section 2 and the mouth of Antelope Creek, with 2.8 and 1.7 for these dates. Grayling fry were most abundant in Antelope Creek where the average of two stations (40 samples) was 15.2 (June 17) and 2.1 fry (July 3). Only a few fry were sampled in Hell Roaring and Corral Creeks in 1952.

From 15 to 25 eastern brook trout were collected (electric shocker) at weekly intervals during the 1952 season to see if their stomachs contained grayling eggs, fry, or fingerlings. Between May 29 and July 1 the contents of 97 stomachs were examined. On May 28, 17 stomachs were examined from trout collected in Red Rock Creek above Section 2. The stomach of one trout (3.1 in. total length) contained five grayling eggs, and one (7.1 in. total length) contained 42. The stomach contents of the other trout consisted of mainly aquatic insects and earthworms. On June 26, 25 trout were captured between Section 2 and the mouth of Antelope Creek. One of these (8.5 in. total length) had 14 grayling fry in its stomach, and five stomachs from small trout (2-4 in. total length) contained 25 fry. Seven other trout stomachs from the collection contained grayling fry remains. No grayling were found in 170 trout stomachs examined after July 1.

Fry are relatively helpless in water currents for about two weeks after hatching and may be carried downstream in large numbers at this time. None was found at the mouth of Red Rock Creek on June 13. Four were captured in this area on June 17, and a noticeable increase was observed July 3.

After the middle of July, fingerlings were no longer observed around the mouth of Red Rock Creek or in protected areas along the creek. On several occasions specimens were observed in weeds along the lake shore near the creek mouth. Some were captured in riffles and pools in Red Rock Creek with a minnow seine or electric shocker.

Brown (1938) reported that grayling fry were smaller than trout fry but the grayling grew faster in the first year of life. His hatchery-reared grayling reached one inch in length at the end of the second month; two and one-half inches by the fifth month; and seven inches at one year. Most grayling in Red Rock Creek were over two inches in length at the end of the second month, and were more than two and one-half inches at the end of three and one-half months (Table 4). The average calculated growth at the end of one year was 6.1 inches.

No scales were evident on the 44 fingerlings collected July 16, 1951 (Table 4). The 13 collected July 28, 1951 and one of the specimens (1.77 in.) collected July 18, 1952 had scales.

TABLE 4.—SIZE OF GRAYLING FRY AND FINGERLINGS IN COLLECTIONS FROM RED ROCK CREEK

| Date | Number | Total length (inches)* Average | Range |
|---|---|---|---|
| 6/14/51... | 7 | 0.50 | 0.43–0.55 |
| 7/ 3/51... | 5 | 1.84 | 0.79–0.98 |
| 7/16/51... | 44 | 1.24 | 1.06–1.38 |
| 7/28/51... | 13 | 2.04 | 1.73–2.28 |
| 8/25/51... | 13 | 2.63 | 2.24–2.87 |
| 9/17/51... | 3 | 3.99 | 3.82–4.09 |
| 6/17/52... | 27 | 0.54 | 0.47–0.59 |
| 7/18/52... | 17 | 1.40 | 0.95–1.77 |
| 8/12/52... | 8 | 2.85 | 2.70–3.08 |
| 9/15/52... | 3 | 4.15 | 4.10–4.22 |

* Measurements from specimens preserved in formalin.

## AGE AND GROWTH

Scale samples were collected from 260 grayling captured in the Upper Red Rock Lake and 95 taken in Red Rock Creek during 1951-1952. Total length was determined to the nearest 0.1 inch and weight to the nearest 0.01 pound. Scales were taken from the left side of the body between lateral line and dorsal fin. Scale measurements were made on the anterior radius of the magnified scale. Uncorrected lengths were determined with a nomograph, assuming a linear relationship between the anterior scale radius and total length of the fish. The averages of the calculated lengths were corrected by the following formula:

$$L_n = \frac{L_t - 2.3}{L_t} L_c + 2.3$$

where $L_n$ = total length at the end of the nth year, $L_t$ = total length at the time of capture, and $L_c$ = total length calculated by direct proportion at the end of the nth year. This was a modification of the formula used by Brown (1943), wherein total length in inches was substituted for the standard length in millimeters used by Brown. Coefficients of condition (C) were calculated for grayling in each age class from the formula:

$$C = \frac{100{,}000W}{L^3}$$

where W = weight in pounds, and L = total length in inches.

Grayling growth rate was greatest the first and second years, and then declined appreciably (Table 5).

Brown (1943) reported that a consistent rate of growth for grayling does not always occur in the lakes he studied. A superior growth in one lake the first

TABLE 5.—SUMMARY OF THE AVERAGE CALCULATED TOTAL LENGTHS, INCREMENTS, AND COEFFICIENT OF CONDITION (C) FOR THE GRAYLING COLLECTED IN 1951 AND 1952 (SEXES COMBINED)

| Age group | Number of fish | Length at capture | (C) | Year of life 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|
| I | 73 | 9.0 | 34 | 6.1 | | | | | |
| II | 78 | 12.6 | 32 | 6.3 | 11.2 | | | | |
| III | 160 | 14.2 | 33 | 6.4 | 11.6 | 13.7 | | | |
| IV | 34 | 15.4 | 27 | 5.9 | 11.4 | 14.0 | 15.0 | | |
| V | 6 | 16.3 | 28 | 5.6 | 10.7 | 13.8 | 15.2 | 16.0 | |
| VI | 2 | 16.2 | 31 | 6.2 | 10.5 | 12.4 | 14.0 | 15.1 | 16.0 |
| Grand averages | | | | 6.1 | 11.1 | 13.5 | 14.7 | 15.6 | 16.0 |
| Increments | | | | 6.1 | 5.0 | 2.4 | 1.2 | 0.9 | 0.4 |
| Number of fish | 353 | | | 353 | 280 | 202 | 42 | 8 | 2 |

year is not always maintained in subsequent years. Grayling from the Red Rock area were approximately the same size as those from Georgetown and Meadow Lakes the first and second year. After the third year they were larger than those in Meadow Lake and smaller than those in Georgetown Lake. Grayling in Great Bear Lake (Miller 1946) live longer and maintain growth longer than those in the Red Rock area, although Red Rock grayling grow faster the first few years.

The oldest grayling found by Brown (1943) in Montana had six complete annuli. Two grayling were interpreted to have six complete annuli from Upper Red Rock Lake. Seven grayling scale samples were secured from Lower Twin Lake during spawning season (July 2, 1952). This lake is located at approximately 9100 feet elevation in the Madison River drainage. One grayling was interpreted to have 10 annuli (15.0 in.); four with nine annuli (14.5 in.); one with six annuli (13.3 in.); and one with three annuli (12.3 in.). These grayling appear to approach the age attained by those from Great Bear Lake (Miller 1946).

A total of 50 spawning fish captured with an electric shocker in Red Rock and Antelope Creeks were aged. Age Group II made up 4 per cent; Age Group III, 92 per cent; Age Group IV, 2 per cent; and Age Group V, 2 per cent. Some grayling spawn at the end of their second year. This was also reported by Brown (1938). The bulk of spawning fish were in Age Group III. A total of 260 scale samples were taken from Upper Red Rock Lake with experimental gill nets after the grayling spawning season (Table 6). Age Group III was also most abundant in Upper Red Rock Lake. In Red Rock Creek after the spawning season, Age Group I was predominent, not including young-of-the-year grayling.

## MANAGEMENT

The fishing season in the study area prior to 1951 was from May 18 to November 15 and the creel limit was 15 grayling. In 1951 the season was changed to open July 1 and the creel limit was reduced to five. Approximately 2,000 rainbow trout were stocked in 1951; eastern brook trout had been stocked also in past years but no stocking records were available. A number of unauthorized plantings are known to

TABLE 6.—NUMBER AND PERCENTAGE COMPOSITION BY AGE GROUPS FROM UPPER RED ROCK LAKE AND RED ROCK CREEK

| Area | Age group | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | Total |
| Upper Red Rock Lake | 56 | 70 | 102 | 25 | 5 | 2 | 260 |
| Per cent | 21.5 | 26.9 | 39.2 | 9.6 | 1.9 | 0.8 | |
| Red Rock Creek | 17 | 11 | 58 | 7 | 2 | | 95 |
| Per cent (all fish) | 18.0 | 11.6 | 61.1 | 7.4 | 2.1 | | |
| Red Rock Creek | 17 | 9 | 12 | 6 | 1 | | 45 |
| Per cent (not including spawning fish) | 37.8 | 20.0 | 26.7 | 13.3 | 2.2 | | |

have been made.

A quantitative study of grayling and other fish species was made in Red Rock Creek during the summer of 1952. The objective was twofold: to determine the relative abundance of the different species of fish and to see what effect removal of other species would have on the distribution and abundance of grayling.

Red Rock Creek was chosen because it harbored grayling year around, and because it supplied most grayling taken by fishermen. Three sections (Fig. 1) were established. The average water velocity and stream width are compared on the basis of September observations.

Section 1 is in the lower portion where silting and bank erosion was prevalent. Bottom materials on riffles are mainly of fine gravel and hardpan, and in pools, either silt or fine sand depending upon velocity of water. Average velocity was 1.7 feet per second and average width 31 feet. Only a few eastern brook trout were in this area. No fishing was observed during the summer.

Section 2 is in the middle portion of the creek. Bottom materials are mainly coarse and fine gravel, but there is some silt in pools, resulting from beaver dam removal. Average velocity was 1.8 feet per second and average width 28 feet. Eastern brook trout and other species were more abundant than in Section 1. Most of the fishing occurred in this section.

Section 3 is in the upper portion of the creek. Bottom materials are mainly gravel and some rubble, silt occurred in deeper pools. Average velocity was 2.2 feet per second and average width 14.5 feet. Eastern brook trout were most abundant in this section. Very little fishing occurred in the area. This part of the creek was recently made accessible to grayling by beaver dam removal.

Each section was divided into two 600-foot areas which were separated by 300-foot buffer zones. In the lower 600-foot (control) area, fish were collected, weighed, measured, (inventoried), fin clipped, and returned. In the upper 600-foot (removal) area, all fish were inventoried, but only grayling were marked and returned.

Each of the three sections were inventoried three times during the summer. The original plan was to make the first inventory during the grayling spawning season; however, high water and large quantities of silt and detritus from newly opened beaver dams made a complete inventory impossible. Some fish were captured by shocking in these areas, nevertheless. More spawning grayling were seen prior to the first inventory than were captured during this inventory.

The electric shock method described by Stefanich (1952) was used to collect fish. Each section was blocked and shocked with alternating-current in 200-foot units. In each inventory 160 volts were used the first trip through each unit, and a maximum of 200 volts was used for subsequent trips. Captured fish were anesthetized in a 0.5 per cent solution of urethane (Gerking 1949). Total length was determined to the nearest 0.1 inch and weight to nearest 0.01 pound. Fish to be returned were fin clipped and held in pens until they recovered from the effects of handling.

The control areas were assumed to represent the species composition during summer. There was a general numerical

increase of fish in the second inventory. This was probably due to increased efficiency of capturing fish. Young fish had reached a more catchable size and water levels were more favorable for operation of shocking equipment in the second inventory. This increase was pronounced in Section 3 where 79 per cent of the eastern brook trout captured were under seven inches total length.

Grayling were captured in all control areas the first inventory, and were most abundant in Sections 1 and 2. By the second inventory they had disappeared from Section 2. Only one grayling (young of the year) was taken in Section 2 during the third inventory. Eastern brook trout were captured in all sections but predominated in Section 3. Whitefish were taken in Sections 1 and 2 but were most abundant in 2 where they progressively increased each inventory. Only 2 of the 17 burbot captured in Section 1 were over 11 inches total length. Longnose suckers were taken in all sections. Although their numbers varied in each section at each inventory, their proportion of total fish remained relatively constant. In Section 2 where longnose suckers were most abundant there was no marked decrease during the summer as was observed by Stefanich (1952) for Prickley Pear Creek. Some decrease in the number of suckers did occur in Sections 1 and 3 (Tables 7 and 9). White suckers (spawners) were abundant in the spring. The majority of larger fish probably returned to the lakes before the first inventory. Only three adults and a dozen or so fingerling were captured during the first inventory. No attempt was made to include freshwater sculpins in the inventory but they were observed to be most abundant in Sections 2 and 3.

In each control area (total of all inventories) the ratio of grayling, to eastern brook trout, to whitefish, to suckers, to burbot was:

Section 1. 14: 6: 3: 78:17
Section 2. 8: 59:37:155: 0
Section 3. 4:208: 0: 66: 0

An inverse distribution occurred between grayling and eastern brook trout and between whitefish and eastern brook trout. Grayling and whitefish were most abundant downstream, and eastern brook trout upstream. Section 2 appeared to be the most favorable environment for whitefish and suckers, and Section 1 for burbot.

The greatest weight per acre of grayling occurred in Section 2 at first inventory. Eastern brook trout weight was highest in Section 3, where it increased each inventory, but this was never over 31.6 per cent of total weight of all fish. Suckers comprised over 60 per cent of the weight in all sections. The total pounds per acre during the third inventory had increased over that of the first inventory in Sections 2 and 3 and decreased in Section 1 (Table 7).

Stefanich (1952) gives a variation of 43.78 to 67.91 pounds per acre of trout for a two-year period in Prickley Pear Creek. The averages for individual inventories in Red Rock Creek varied from 10.34 to 18.88 pounds per acre of trout. The highest weight of trout per acre in Section 3 (52.58 pounds) was within the Prickley Pear Creek range, but was much less than the 94.40 pounds per acre of eastern brook trout in Hunt Creek, Michigan (Shetter and Leonard 1943). Suckers varied from 74.07 to 140.70 pounds per acre

in the inventories of Red Rock Creek, as compared to the 11.20-145.66 pounds per acre in Prickly Pear Creek.

There was some difference in numbers and weight of fish in the control and removal areas in each section at first inventory. These variations were not believed to be significant.

Grayling did not occur in sufficient numbers to evaluate effects of fish removal. Eastern brook trout repopulated the removal areas quickly (Tables 7, 8, 9). Forty eastern brook trout were removed from Section 2 (plus those removed by anglers), in the first two inventories. Six more were captured in the third inventory than in the first inventory. There was little reduction of eastern brook trout before the third inventory in Sections 1 and 3. In Section 2, more whitefish were captured each subsequent inventory than were removed in the preceding inventory. Suckers were reduced in numbers in all sections by the third inventory.

The total weight of grayling (third inventory) in removal areas was slightly higher than in control areas. The weight of eastern brook trout was reduced in all removal areas by the third inventory (Tables 7, 8, 9). In Section 2, weight of whitefish was about equal in first and third inventories, even though 21.7 pounds were removed preceding the

TABLE 7.—NUMBER, WEIGHT, AND POUNDS OF FISH PER ACRE CAPTURED IN SECTION 1 OF RED ROCK CREEK DURING EACH INVENTORY PERIOD, 1952

| Species and inventory period | Control area | | | | | Removal area | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Per cent | Weight | Per cent | Pounds per acre | Number | Per cent | Weight | Per cent | Pounds per acre |
| June 28–July 1 | | | | | | | | | | |
| Grayling | 9 | 23.7 | 3.03 | 10.4 | 7.10 | 4 | 12.1 | 0.66 | 4.4 | 1.55 |
| Eastern brook | 1 | 2.6 | 0.08 | 0.3 | 0.19 | 3 | 9.1 | 0.92 | 6.1 | 2.15 |
| Whitefish | 0 | .... | ..... | .... | ..... | 2 | 6.1 | 0.19 | 1.3 | 0.44 |
| Suckers | 26 | 68.4 | 25.99 | 88.8 | 60.87 | 23 | 69.7 | 13.17 | 87.7 | 30.84 |
| Burbot | 2 | 5.3 | 0.16 | 0.5 | 0.37 | 1 | 3.0 | 0.08 | 0.5 | 0.19 |
| Total | 38 | | 29.26 | | 68.53 | 33 | | 15.02 | | 35.17 |
| August 12–14 | | | | | | | | | | |
| Grayling | 5 | 7.9 | 0.84 | 3.7 | 1.97 | 4 | 14.3 | 0.04 | 0.7 | 0.09 |
| Eastern brook | 4 | 6.4 | 1.68 | 7.3 | 3.93 | 8 | 28.6 | 1.85 | 30.3 | 4.33 |
| Whitefish | 3 | 4.7 | 0.03 | 0.1 | 0.07 | 7 | 25.0 | 0.34 | 5.6 | 0.80 |
| Suckers | 41 | 65.1 | 18.50 | 80.7 | 43.33 | 8 | 28.6 | 3.74 | 61.3 | 8.76 |
| Burbot | 10 | 15.9 | 1.89 | 8.2 | 4.43 | 1 | 3.5 | 0.13 | 2.1 | 0.30 |
| Total | 63 | | 22.94 | | 53.73 | 28 | | 6.10 | | 14.29 |
| September 15–17 | | | | | | | | | | |
| Grayling | 0 | .... | ..... | .... | ..... | 1 | 25.0 | 0.01 | 1.1 | 0.02 |
| Eastern brook | 1 | 5.9 | 0.28 | 1.7 | 0.66 | 2 | 50.0 | 0.85 | 94.5 | 1.99 |
| Whitefish | 0 | .... | ..... | .... | ..... | 0 | .... | ..... | .... | .... |
| Suckers | 11 | 64.7 | 15.76 | 96.6 | 36.91 | 1 | 25.0 | 0.04 | 4.4 | 0.99 |
| Burbot | 5 | 29.4 | 0.27 | 1.7 | 0.63 | 0 | .... | ..... | .... | .... |
| Total | 17 | | 16.31 | | 38.20 | 4 | | 0.90 | | 2.10 |

TABLE 8.—NUMBER, WEIGHT, AND POUNDS PER ACRE OF FISH CAPTURED IN SECTION 2 OF RED ROCK CREEK DURING EACH INVENTORY PERIOD, 1952

| Species and inventory period | Control area | | | | | Removal area | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Per cent | Weight | Per cent | Pounds per acre | Number | Per cent | Weight | Per cent | Pounds per acre |
| June 28–July 1 | | | | | | | | | | |
| Grayling | 7 | 11.8 | 4.40 | 8.9 | 11.29 | 10 | 14.3 | 7.80 | 12.2 | 20.01 |
| Eastern brook | 10 | 17.0 | 1.55 | 3.1 | 3.98 | 10 | 14.3 | 2.53 | 4.0 | 6.49 |
| Whitefish | 3 | 5.1 | 1.67 | 3.4 | 4.28 | 15 | 21.4 | 13.32 | 20.8 | 34.17 |
| Sucker | 39 | 66.1 | 41.68 | 84.6 | 106.91 | 35 | 50.0 | 40.19 | 63.0 | 103.09 |
| Total | 59 | | 49.30 | | 126.46 | 70 | | 63.84 | | 163.76 |
| August 12–14 | | | | | | | | | | |
| Grayling | 0 | .... | ..... | .... | ..... | 0 | .... | ..... | .... | ..... |
| Eastern brook | 38 | 38.4 | 3.00 | 5.2 | 7.70 | 30 | 30.6 | 3.83 | 6.2 | 9.82 |
| Whitefish | 14 | 14.1 | 9.70 | 16.7 | 24.88 | 19 | 19.4 | 8.38 | 13.7 | 21.49 |
| Sucker | 47 | 47.5 | 45.41 | 78.1 | 116.48 | 49 | 50.0 | 49.04 | 80.1 | 125.79 |
| Total | 99 | | 58.11 | | 149.06 | 98 | | 61.25 | | 157.10 |
| September 15–17 | | | | | | | | | | |
| Grayling | 1 | 1.0 | 0.01 | trace | 0.03 | 1 | 1.1 | 0.64 | 1.6 | 1.64 |
| Eastern brook | 11 | 10.8 | 1.32 | 1.5 | 3.39 | 16 | 17.2 | 0.43 | 1.0 | 1.10 |
| Whitefish | 21 | 20.6 | 7.20 | 7.9 | 18.47 | 48 | 51.6 | 12.91 | 32.2 | 33.11 |
| Sucker | 69 | 67.6 | 81.89 | 90.6 | 210.05 | 28 | 30.1 | 26.14 | 65.2 | 67.05 |
| Total | 102 | | 90.42 | | 231.94 | 93 | | 40.12 | | 102.90 |

TABLE 9.—NUMBER, WEIGHT, AND POUNDS PER ACRE OF FISH CAPTURED IN SECTION 3 OF RED ROCK CREEK DURING EACH INVENTORY PERIOD, 1952

| Species and inventory period | Control area | | | | | Removal area | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Per cent | Weight | Per cent | Pounds per acre | Number | Per cent | Weight | Per cent | Pounds per acre |
| June 28–July 1 | | | | | | | | | | |
| Grayling | 1 | 1.6 | 0.78 | 4.4 | 3.82 | 1 | 1.1 | 0.83 | 1.8 | 4.07 |
| Eastern brook | 50 | 79.4 | 5.48 | 31.6 | 26.85 | 57 | 62.6 | 4.51 | 10.0 | 22.10 |
| Suckers | 12 | 19.0 | 11.11 | 64.0 | 54.44 | 33 | 36.3 | 39.98 | 88.2 | 195.90 |
| Total | 63 | | 17.37 | | 85.11 | 91 | | 45.32 | | 222.07 |
| August 12–14 | | | | | | | | | | |
| Grayling | 3 | 2.1 | 1.06 | 1.7 | 5.19 | 0 | .... | 0 | .... | ..... |
| Eastern brook | 102 | 71.3 | 8.29 | 13.2 | 40.62 | 87 | 80.6 | 8.42 | 23.7 | 41.26 |
| Suckers | 38 | 26.6 | 53.55 | 85.1 | 262.40 | 21 | 19.4 | 27.18 | 76.3 | 133.18 |
| Total | 143 | | 62.90 | | 308.21 | 108 | | 35.60 | | 174.44 |
| September 12–14 | | | | | | | | | | |
| Grayling | 0 | .... | ..... | .... | 0 | 0 | | 0 | .... | ..... |
| Eastern brook | 56 | 77.8 | 10.73 | 30.9 | 52.58 | 33 | 75.0 | 3.04 | 15.2 | 14.90 |
| Suckers | 16 | 22.2 | 23.98 | 69.1 | 117.50 | 11 | 25.0 | 16.97 | 84.8 | 83.15 |
| Total | 72 | | 34.71 | | 170.08 | 44 | | 20.01 | | 98.05 |

third inventory. This may have been influenced by spawning whitefish moving into the removal area. The weight of suckers decreased each inventory in Sections 1 and 3. In Section 2 there was an increase in the second inventory. At third inventory most fish in removal areas were of smaller size than those in control areas.

In Sections 2 and 3 total pounds of all fish per acre decreased in removal areas and increased in control areas. In Section 1 a decrease in total pounds occurred in both control and removal areas. Silting and loss of cover due to bank erosion occurred in this section during inventory periods. In some parts of the lower creek, bank erosion was intensified by cattle which frequented the creek during August and September. An additional 600-foot section was inventoried September 17. This was located about half way between Section 1 and the mouth of Red Rock Creek, where erosion resulting from livestock was prevalent. A total weight of 8.72 pounds of fish were captured.

The reduction of grayling in both the control and removal areas of Section 2 by the time of second inventory (Table 8), resulted partly from removal of grayling by fishermen. The season opened July 1. Most grayling caught in Red Rock Creek were taken within a mile on either side of Section 2. This was the only part of the creek easily accessible to fishermen. At the end of July, 48 grayling had been checked in creels. Six (35.3 per cent) of the 17 grayling marked in Section 2 the first inventory were included in this total. As near as could be determined from fishermen, the marked and four unmarked grayling were caught in or near Section 2. In August, three unmarked grayling were checked in creels; one of these was taken from the removal area of Section 2 immediately before the second inventory. No grayling were taken in this inventory within this section. Few grayling were taken by fishermen after July in 1951-1952.

## MANAGEMENT RECOMMENDATIONS

FISHING SEASON—It is recommended that the present fishing season (July 1 to Sept. 15) be maintained and that Red Rock and Swan Lakes and that portion of Red Rock Creek on the waterfowl refuge be closed to fishing the entire year. This will give adequate protection for spawning grayling and permit a return to the Upper Red Rock Lake before fishing begins.

DAILY LIMITS.—It is recommended that the present limit of five grayling be reduced to two. The aggregate limit on cutthroat and lake trout should remain at 15 fish, not to exceed 10 pounds and one fish, and not to include more than five fish less than seven inches in length. Size, number, and weight restrictions should be removed on rainbow trout, eastern brook trout, and whitefish.

IRRIGATION.—It is recommended that an investigation be made of legal "water rights" for creeks entering the refuge. The most important would be Red Rock, Tom, Odell, and Metzel Creeks. The latter three are almost completely dewatered where they enter the refuge for certain periods during the summer.

Control of irrigation on the refuge should be vested in the refuge manager. At present water from lake tributaries (mainly Red Rock and Tom Creek) is

used to irrigate hay and grazing land leased to ranchers by the refuge. Irrigation should be curtailed wherever possible on the refuge, and no new developments should be permitted. Where permitted, irrigation should not begin before July 15 in order to protect the grayling spawners and fry.

The average number of grayling fry per cubic foot of water was estimated each year in three irrigation ditches originating in Red Rock Creek (Fig. 1). This estimate was based on 120 samples from each ditch, 60 for each of two sampling periods. The sampling period, June 17-19, 1951 had an average of 1.5 fry in Ditch 1, 1.0 fry in Ditch 2, and 2.5 fry in Ditch 3. The second sampling, June 26 - July 3, had 1.1, 1.5, and 3.1 fry respectively. While fry decreased in Ditch 1, and increased in 2 and 3 between sampling periods, there was a noticeable decrease in Red Rock Creek. In 1952 traces of fry were sampled in Ditch 1, 0.6 fry in Ditch 2, and 0.5 fry in Ditch 3 (June 17-19). The second sampling period (June 26 - July 3) there were traces in Ditch 1, 0.9 fry in Ditch 2, and 0.7 fry in Ditch 3. Approximately 100 "spent" grayling were counted dead in Ditch 1, in 1951 and seven were found dead in Ditch 1 and 14 in Ditch 3 in 1952.

Within two weeks after the second sampling period, all grayling (young of the year) in the lower part of the ditches were dead. Some survived near ditch headgates. However, all fry and adults that entered the ditch were undoubtedly lost. All observed adult losses in irrigation ditches occurred between May 24 and June 14. Most of the loss of young-of-the-year grayling was between hatching and the first of July, or when they are relatively helpless in water currents.

ARTIFICIAL STOCKING.—The complete cessation of stocking exotic species in this area was recommended as early as 1950. This recommendation should be strictly adhered to. Only grayling and cutthroat trout should be stocked in the drainage above the Lima Dam. Further experimental stocking of grayling fry may meet with success. Stocking of grayling (six or more inches in length) in the more heavily fished waters such as Elk Lake, Odell and Red Rock Creeks would probably provide some grayling fishing.

BEAVER CONTROL.—It is recommended that all beaver and beaver dams be removed from tributaries of the Upper Red Rock Lake. Elk Springs Creek, part of Tom Creek, and six small spring creeks on the south shore of Upper Red Rock Lake have spawning areas not accessible to grayling because of beaver dams. Beaver dam removal above the last springs in Tom Creek is not recommended until a minimum flow of water is established by enforcement of legal water rights. Beaver dam removal without elimination of beaver on spring-fed creeks is useless since dams are rebuilt almost immediately. On Red Rock Creek no repairs to dams were observed until September. This allowed ample time for grayling to spawn.

Red Rock Creek and its tributaries and part of Tom Creek were made accessible by removal of approximately 100 beaver and 90 dams in 1951 and 1952. Until beaver are eliminated from these areas, beaver dams will need to be removed prior to each year's grayling

spawning run in order to keep the stream accessible.

EROSION AND SILTING.—Number and weight of all fish was lowest in Section 1 of Red Rock Creek (Table 7) where erosion of banks, and silting was prevalent. Perhaps after a more complete investigation, fencing of the creeks against livestock in this area might be justified.

RECLAIMING WATER FOR GRAYLING.—Culver (Widows) Pond, Buck Pond, and Shambow Pond (artificial impoundments, Fig. 1) contain rainbow and eastern brook trout at present. These fish should be removed by poisoning and grayling introduced. Buck Pond is the only one not at the head of its individual drainage. It has a small runoff from Elk Lake which can be isolated from fish movements by a coarse gravel fill in the canyon at the lower end of the lake. If this is done, these ponds would be isolated and could be managed exclusively for grayling. They have some suitable spawning areas in their short spring inlets.

Two ponds, located off the refuge appear suitable for grayling stocking, if permission can be secured from the owners to poison out the species present.

It may be feasible to poison certain creeks but not without further investigation.

## MANAGEMENT IN OTHER AREAS

Prior to 1951, grayling regulations were applied on a statewide basis. The fishing season extended from May 18 to November 15, and the creel limit was 15. In 1951, the opening of the season was changed to July 1 and the creel limit reduced to five grayling. Between 1950 and 1952, 10½ million fry and 11,894 fingerlings (5-6 in.) were planted in western Montana (Mont. Fish & Game Comm. 1953). Catches of grayling between 1948 and 1952 were reported from 22 lakes and 27 streams. This fishery is believed to be maintained mainly by artificial stocking. Most of the lakes containing grayling today were originally barren of all fish. Some are known to produce large grayling populations.

It is recommended that possibilities for enlarging the present grayling range be investigated. All barren mountain lakes which still exist in Montana and which are suitable, should be reserved for grayling only. A number of small mountain lakes already stocked with species other than cutthroat or golden trout might be poisoned out and then stocked with grayling. Headwaters of creeks that are isolated to upstream movements of fish by artificial or natural barriers offer an opportunity to develop grayling water. Over a period of years, it may be possible to reclaim a few entire creeks by poisoning and installing barriers to keep out other fish.

## SUMMARY

1. An investigation of grayling in the Centennial Valley, Montana, was made during the summers of 1951 and 1952 to develop a management plan for grayling in one area of its original range.

2. In 1951 grayling were found in two lakes and five creeks. They were most abundant in Upper Red Rock Lake where the catch (1951 & 1952) with 125-foot graded experimental gill nets averaged 2.05 per hour.

3. Grayling were most abundant in

Red Rock Creek during May and June during spawning and gradually decreased during the summer. In 1952 the average numbers captured with an electric shocker in 600-foot sections of stream were 5.3 (June 28 - July 1), 2.0 (Aug. 12-14), and 0.5 (Sept. 15-17).

4. A total of 370 grayling were marked, and 14 marked fish were recovered.

5. In 1952 spawning was observed between May 19 and June 6 in Red Rock Creek, and between May 23 and June 1 in Antelope Creek. No spawning was observed or grayling eggs found in bottom materials composed of sand or silt.

6. The period between fertilization and hatching of the eggs was estimated to be 14-19 days where the water temperatures varied from 38 to 61° F.

7. The decrease in numbers of grayling fry during June in Red Rock Creek was partly due to predation and downstream movement.

8. The average calculated total lengths in inches for the various age groups of grayling in the Centennial Valley were: Age Group I, 6.1; Age Group II, 11.1; Age Group III, 13.5; Age Group IV, 14.7; Age Group V, 15.6; and Age Group VI, 16.0.

9. An experiment removing all fish except grayling in sections of Red Rock Creek was tried. Grayling did not occur in sufficient numbers to evaluate effects of fish removal.

10. At the end of one month's fishing, 6 (35.3 per cent) of the 17 grayling marked in Section 2 of Red Rock Creek were checked in creels.

11. A management plan is proposed to control fishing, irrigation, artificial stocking, beaver, and erosion.

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# THE VALUE OF BICOLOR AND SERICEA FIELD BORDER PLANTINGS TO QUAIL IN ARKANSAS[1]

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## Introduction

During a three-year investigation (July, 1946 - July, 1949), 1,335 miles of field border plantings and natural field borders were examined to determine use by bobwhite quail and other wildlife. Factors of importance in the management of border strips including type, cost and size of planting, location in relation to land use, and use of plantings by farmers are reported herein. Borders were located throughout Arkansas on farms and wildlife management areas.

Of interest is a comparison of various types of plantings in which bicolor (*Lespedeza bicolor*) does not seem to come up to standards that have been claimed for it.

Arkansas has probably over-emphasized a program that has not been sufficiently investigated. In the fiscal year ending June 30, 1950, the southeastern states obligated a total of approximately one-half-million dollars for farm game habitat improvement projects. Most projects were devoted to production and planting of bicolor and multiflora rose (*Rosa multiflora*) (Pierce 1951). Pierce also pointed out that investigation is badly needed and that research projects usually have been poorly timed.

Two biologists were assigned to the investigation: Donald E. Rush conducted studies in the northern portion of the state and the author in the southern portion. Each established a farmland study area which was typical of a major portion of his division. These areas were set up to include various types of border plantings in order to permit study of planting procedures and plantings from one to three years of age.

In addition, a route of established sericea (*Lespedeza cuneata*) and bicolor plantings was observed by each investigator throughout his portion. Each route was checked at least once a month. Approximately 90 plantings were included. Many other plantings were examined less frequently. Although most plantings were border strips, some were in the form of small fields and patches in various locations. They occurred on different soil types and were of sufficient variety to present an over-all picture. A total of 390.6 miles of established border plantings were checked for wildlife use. Approximately 50 miles of bicolor were included. Natural borders adjacent to these established strips were also examined. A natural border was a field edge as utilized by the landowner.

Data were compiled on a variety of types of natural borders, but as study progressed it was noted that from the standpoint of wildlife use these had little significance. Wildlife use depended upon such a large number of factors that it was very difficult to classify borders satisfactorily. Food and cover conditions varied considerably over

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short distances regardless of land use or timber type. Therefore it was realized that wildlife usage data were needed on a large sample of natural borders, including a cross-section of types found in the state, for comparison with use by wildlife of planted borders. A total of 922 miles of natural field borders were checked for wildlife use.

Use of annual plantings of hegari cane (*Sorghum vulgare*) and red ripper peas (*Vigna sinensis*) was studied from December through April, 1948-49; 23.2 miles of these plantings were checked. These plantings were maintained by state personnel on public lands and were inspected to include information on plants known to be highly palatable to quail.

Altogether, 1,335.8 miles of natural field borders, planted borders of bicolor, sericea, and annual lespedezas and other wildlife plantings were checked.

## METHODS

Use of a border was indicated by droppings, tracks, dusting sites, roosts, feathers, etc., or presence of quail (*Colinus virginianus*) or other wildlife. Each of the above that could be identified as a separate visit to the border was recorded as one sign. The lengths of the various border plantings and natural borders were measured, and for a comparison of use the average distance between signs was figured.

In checking use of a sericea meadow, natural border, or the one-to-two-acre food patches, a strip around the border of the field or patch 15 yards in width was checked; this was the average width of the border strips studied. This strip was gone through once only, and the observer usually walked in the center of this strip. The ground was closely watched for sign. The range of vision varied, depending upon density of the stand and season. The border strip plantings were also gone through once only, usually about the center of the planting.

## RESULTS AND DISCUSSION

Use and value of border strips to quail:

Sericea was used at the ratio of 3.53 : 1 over natural borders on a year-around basis. During the fall and winter months, November through March, sericea was used 6.20 : 1 over natural borders. The year-around average distance between quail signs in sericea plantings was .36 mile; November through March, .25 mile; and during the peak of use in February and March, .16 mile.

Sericea was used chiefly for roosting, cover, and feeding upon insects. It was of less importance for nesting cover.

Bicolor was used slightly less than sericea. The year-around average distance between quail signs in bicolor plantings was .42 mile; November through March, .31 mile; and during the peak of use in February and March, .25 mile. Signs indicated that the chief use of bicolor was for feeding.

The annual food patches were used much more heavily by quail than any other type of planting studied. The distance between signs was only .08 mile.

The average distance between quail signs in natural borders was 1.27 miles on a year-round basis. Use from month to month varied greatly and was evidently dependent upon a large number of factors. From November through March the distance between signs

averaged 1.55 miles and in February and March, 1.44 miles. Greatest use of natural borders was during August, September, and October when the figure was .75 mile.

Observation of the few plantings in which Korean or some other annual lespedeza and sericea were combined showed that quail used them much more than sericea alone. Annual lespedezas are recognized as one of the most important quail foods (Graham, 1941), and sericea serves its best purpose as a cover plant.

Use and value of border strips to other wildlife:

Apparently, cottontail rabbits (*Sylvilagus floridanus*) benefit a great deal from these plantings, because rabbit signs were much more common than quail signs in both sericea and bicolor. Bark and leaves of both plants are eaten.

A small amount of trapping of rodents indicates that they may be more abundant in thick sericea plantings than in thick broomsedge and grass stands, which are very favorable cover for rodents. Old sericea plantings which are not mowed have heaviest concentrations of rodents. Quail used these plantings very little, but use by rabbits was heavy. Cotton rats (*Sigmidon hispidus*) and whitefooted mice (*Permoyscus sp.*) were the species usually taken. In 338 trap nights, in sericea, 53 rodents were captured, or 16 percent of the traps were successful. In natural cover, 17 rodents were captured in 355 trap nights, or five per cent of the traps were successful. The traps were set at 6-foot intervals down the cruising line previously described. This indicates that dense sericea plantings should be mowed every year or two for increased wildlife use and reduction of rodents.

In some of the plantings in the southern part of the state, pocket gophers (*Geomys breviceps breviceps*) are common. They seem to prefer the roots of sericea and bicolor over those of many other plants in this section. In a few plantings they are very destructive.

Types of plantings:

Of the group of 90 plantings on which monthly observations were made throughout the study, 9 were meadows and 81 were in the form of strips and patches. Many of the sericea strips were wide and were mowed for hay; 79 were sericea plantings; 6 were bicolor plantings; and 5 were a combination of sericea and bicolor.

In the "follow-up" of the many bicolor plants distributed, which was made during the study, it was estimated that there were not over 50 successfully established bicolor plantings in the state. This was after six years of operation of the program and a distribution of 775,070 bicolor plants and 2,284 pounds of bicolor seed. The majority of the plantings which were successful were made by personnel of the Game and Fish Commission. This includes most of the bicolor strips that were studied.

Cost and size of plantings:

Sericea: The average-sized sericea border strip was 208 by 15 yards (about 2/3 of an acre). The average total cost of establishing a strip this size was approximately $8.

Bicolor: The relatively small number of bicolor plantings available for study, plus the fact that some of these were planted for special purposes by the

state, gave little information on average size of bicolor plantings as used by farmers. The size of bicolor strip recommended in this state is six rows wide by 100 yards long and requires 2,000 plants (Hunter, *et al.*, 1950). As quail use of sericea and bicolor was approximately equal, it may be stated, for comparison, that planting 2/3 of an acre of bicolor would cost about $42 including the price for 9,800 bicolor seedlings at $3 per 1,000. Seeding has not proved to be an effective method of establishing bicolor strips in Arkansas. A study of covey ranges before and after developments with a variety of types and sizes of plantings would be valuable.

Annual: The annual plantings were from one to two acres in size. The cost of planting a 2/3-acre food patch is approximately the same as for the sericea.

Location in relation to land use:

Seventy-six of the 90 plantings regularly studied were adjacent to the woods. The 81 strips and patches were located as follows: 29 in hay fields, 28 in cultivated fields, 15 in idle fields, and nine in pastures.

The majority of the successfully established plantings were located to take advantage of existing fences for protection from grazing. Some of these, however, were grazed after crops were harvested, which caused the seeds to be shattered and the cover value much reduced, especially with bicolor.

Use and value of the plantings to farmers:

Twenty-five of the 79 sericea plantings were regularly mowed for hay; 61 were helping retard soil erosion; and 72 were planted solely or partly for wildlife.

The average yield of hay was 30 bales per acre per cutting. In a favorable season, three cuttings were sometimes made. In the northern part of the state, one farmer had a sericea meadow 14 years of age which produced over 100 bales per acre. Some farmers are dissatisfied with sericea hay, but this is usually because of improper mowing or handling. When not mowed at the proper stage it is less palatable to cattle (McKee, 1946).

The combination of sericea and annual lespedeza seems to control erosion better than bicolor and has some additional advantages, which are discussed in the following paragraphs. Pieters (1939) and McKee have well described the multiple uses of these plants.

Sericea and the annual lespedezas are acceptable to the farmers. This is borne out by the fact that the University of Arkansas Agricultural Extension Service estimated there were 338,000 acres of sericea and annual lespedezas in pasture, 1,000,000 pounds of Korean seed harvested, and 4,000,000 pounds of Kobe seed harvested in 1951. Figures from the Production and Marketing Administration for the same year show that they made payment to farmers for planting 292,000 pounds of sericea in pastures, 6,400,000 pounds of annual lespedezas in pastures, and 191,219 acres of annual lespedezas in cover crops. Figures on the use of the plants in meadows were unavailable. These figures demonstrate that this is a sufficient volume of material to benefit quail. Of 23 retail seed dealers in the areas where bicolor has been planted, only two stated that they had received requests from farmers for bicolor seed or plants during 1953. It is usually

difficult to get farmers to try new practices on their land, and border strips are no exception.

Pieters (1939) states that for land of low fertility few, if any, plants will furnish as good cover and at the same time provide as much summer grazing as sericea. One of the sericea plantings studied was pastured regularly. This caused the plants to produce a very dense growth, and the plants were still able to produce seed. Research to develop a strain of sericea with seeds more palatable to wildlife would be of great value to farm game programs.

The seed of sericea and annual lespedezas are easily obtained and planted; whereas production of bicolor plants involves nursery procedures and often special equipment and handling.

Sericea and the annuals can be mowed for hay and serve many additional needs of the farmer; whereas bicolor is of little value except as quail food and cover. Bicolor will withstand cutting, disking, and burning; and sericea will withstand cutting, burning, and grazing. Many of the farmers who were induced to plant a bicolor strip, later allowed it to be grazed or plowed it up to put the land back into cultivation. Although some of the sericea plantings were also lost, most of them that were utilized for hay or other purposes were maintained. Farmers often purchased additional seed and enlarged the planting or made other plantings. The importance of proper use of the plants has been pointed out by Durell (1952).

During years of drought the annual food patches containing peas and the annual lespedezas usually produced more food because of the fact that the seed of these plants matures earlier in the season. In the very dry growing seasons of 1952 and 1953 the majority of the bicolor plants in new strips were killed. Bicolor plots often failed to mature seed because of early frosts.

## CONCLUSIONS

From an examination of the foregoing data it appears that we have yet to find a plant which used alone will fulfill all of the requirements of a border strip planting and be of such value to the average farmer that he will continue to plant it and substantially increase the acreage of land productive of wildlife on farms throughout Arkansas. Bicolor will probably continue to be of importance, at least for some time, on lands where management of wildlife is a primary objective.

Use of sericea with an annual lespedeza seems to be the practice best suited to conditions in Arkansas.

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# THE PRODUCTION OF ASPEN AND ITS UTILIZATION BY BEAVER ON THE HUNTINGTON FOREST

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## Introduction

The ecological history of our forests reveals a close relationship between fire, aspen (*Populus* spp.) and beaver (*Castor canadensis*). Aspen follows forest fires for two reasons: aspen seeds require mineral soil in which to germinate and being wind-blown they are among the early tree seeds to invade burned-over areas. Aspen has always been the favorite food of beaver and distribution of this animal has been governed largely by distribution of aspen. Presence of aspen and beaver may be said to reflect the ravages of forest fires. Both aspen and beaver are characteristic of an early stage of succession. From the standpoint of the silviculturist, the principal values of aspen seem to be its action as ground cover, earth stabilizer, mulch producer and shelter for more desirable timber species. Until recent years, aspen was considered a weed species and had little commercial value. Now it is used as pulpwood, excelsior and to a limited extent as building material. In remote areas where it is difficult to reach, it is still a weed species since its sale value does not pay for harvesting.

From the standpoint of economic return from some areas, however, perpetuation of aspen for beaver food under proper management may prove to be the best use of the land. Aspen stands are favorable for grouse, deer, fox, varying hare and other upland game, while beaver ponds provide habitat for fish, ducks, muskrat, mink, otter and other species. Each adds to the economic or commercial value of the aspen stand.

This study was conducted on the Huntington Forest, a tract of about 15,000 acres, situated ten miles east of Long Lake, New York. The southeast corner of the tract lies in the village of Newcomb. The Forest is quite typical of much of the Central Adirondack Region and therefore information secured in this study should be pertinent to much of the Adirondacks. Further information on the Huntington Forest may be obtained from Johnson (1937) and King *et al* (1941).

The main objectives were to acquire information on the following subjects: (1) rate of growth of aspen on the Huntington Forest, (2) amount of beaver food produced by aspen of various sizes, (3) amount of beaver food per acre represented by aspen of various diameter classes, (4) age and size of aspen producing the greatest amounts of beaver food per acre per year, (5) degree of utilization of aspen by beaver by diameter classes, (6) volume of wood represented per acre per diameter class, and (7) most advantageous rotation period of aspen for production of beaver food. Information secured in this study is presented to

show the possibilities of this and similar areas, for production of beaver under intensive management.

Trembling aspen (*Populus tremuloides*) and large-toothed aspen (*Populus grandidentata*) occur in the area covered by this study. Large-toothed aspen is limited largely to higher sites in the Deer Lake area, and for that reason is not considered in the food studies. No attempt was made to separate the two species when collecting information from trees already felled by beaver. Undoubtedly a few large-toothed aspens are included in such observations.

## METHODS

Set procedures were utilized in collecting data for this study. One hundred eighteen trembling aspen were cut, representing size classes from one-half inch to ten inches in diameter. Height of each tree was measured and all leaves and twigs to one-half inch diameter (outside bark) were cut and weighed. All bark was removed from twigs and limbs from one-half inch diameter to four inches diameter from 109 trees which were representative of the stand. All diameters were measured with calipers, all lengths measured with a steel tape, and all weights taken on a spring balance. Ring counts were taken at breast height on 101 trees recently felled by beaver to determine rate of growth. A second set of ring counts was made on the same trees at the last or terminal cut made by beaver to see whether or not the growth rate was the same, and to determine average age of the terminal part of the tree actually utilized by beaver. Percent, or degree of utilization, was estimated on over 900 trees and degree of utilization correlated with the d.b.h. (diameter at breast height). Utilization is used here in the same broad sense that it was by Aldous (1938): "Any trees or their parts removed from the vicinity of cutting, regardless of ultimate disposition, were considered utilized." Counts were made of the number of trees per acre of the different diameter classes.

Most of the data were collected from an aspen stand situated east of Deer Lake which is not one of the best sites on the Huntington Forest, but quite typical of land to the north and west. The area shows less production of aspen than would be found on more favorable sites.

A considerable area north and east of Deer Lake was heavily burned in 1903 by a post-logging fire. Following the burn a heavy stand of aspen established itself on the portion covered in this study. As a result most trees in this stand grew under stiff competition and have tall straight boles and relatively small crowns. At the time these data were collected (1941 and 1947) beaver had practically clear-cut the aspen for distances varying from 50 feet to 250 feet from the lake shore and for a like distance from the shores of a series of beaver ponds built along the inlet to Deer Lake.

## RATE OF GROWTH OF ASPEN IN DIAMETER

One hundred trees were selected at random varying from 3.25 inches to 13 inches d.b.h. These trees were considered to be representative of the trees east of Deer Lake.

Average annual ring count was 28.25 and average d.b.h. was 7.03 inches. Thus, average rate of growth was .249

inch per year. Since the ring counts, which varied from 21 to 36, were made in 1941, the trees studied reached breast height from two to seventeen years following the burn. This lag and variation is to be expected.

A second set of increment borings, made at the terminal end of the log where beaver had made their last cut, showed an average diameter growth rate of .227 inch per year and gave the average age of the terminal part of the tree utilized by beaver as 15.6 years.

A significantly different rate of growth was shown by small trees up to one inch in diameter. Twenty-three trees in the one-inch class were cut close to the ground and the rings carefully counted. Average rate of growth shown on these very young trees was .162 inch per year.

A second check on growth rate was furnished during the count of the number of one-inch trees per acre. The three plots selected were in clear-cut areas where aspen had reseeded. Average diameter growth rate was .111 inch per year.

These two observations are in close agreement since aspen seedings may have been delayed for a year or two after clear-cutting. Such a lag would make the average growth rate for the three plots about .142 inch per year.

Increment borings from the 100 trees showed slow initial growth rate followed by a fairly constant diameter growth after reaching the one-inch size. Therefore, figures used in this study are the following: for the first inch in diameter, .15 inch per year; from one inch upward, a rate of growth of .249 inch per year.

### RATE OF GROWTH OF ASPEN IN HEIGHT

Density of stand is one of several factors that affect growth in height. The stand under consideration was dense, even-aged and the trees were tall with relatively small crowns. Heights of 108 trees used in this study are shown by diameter classes in Table 1. These figures show a maximum height growth in the three-inch diameter class and reflect a progressive increase in rate of height growth to that size, followed thereafter by progressively slower growth.

### NUMBER OF ASPEN TREES PER ACRE

All aspen stands were fairly even-aged since they developed soon after

TABLE 1.—ASPEN GROWTH IN HEIGHT

| Diameter Class (Inches) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Age (Years) | 6.6 | 10.6 | 14.6 | 18.6 | 22.7 | 26.7 | 30.7 | 34.7 | 38.7 | 42.7 |
| Average Height (Feet) | 10.85 | 24.49 | 36.20 | 44.00 | 46.78 | 48.84 | 52.33 | 50.50 | 52.70 | 58.00 |
| Average Yearly Growth (Feet) | 1.64 | 2.31 | 2.48 | 2.36 | 2.06 | 1.83 | 1.70 | 1.45 | 1.36 | 1.36 |

a burn. Some obvious factors which determine the number of aspen trees that occur per acre for different diameter classes are: density of original stocking, quality of site, effect of competing species, and silvicultural practices.

Sample plots were selected on the basis of dominance of aspen and average d.b.h. Each plot represented one square chain or one-tenth of an acre. Trees under three inches d.b.h. were recorded to the closest 1/2 inch, while trees over three inches d.b.h. were recorded to the closest inch.

The areas were so chosen as to be representative of aspen stands in this region. Larger diameter classes show an increased percentage of the stand made up of other tree species (Table 2).

## PRODUCTION OF BEAVER FOOD PER TREE

The average amount of beaver food per tree was determined from measurements of trees representative of various diameter classes in dense stands and with relatively small crowns. Trees of the six- to ten-inch classes, however, had been dominant in small clearings or had been by-passed by beaver. These had relatively larger crowns.

Leaves and twigs up to one-half inch in diameter, outside bark measurement, were considered food that beaver could utilize in their entirety. Total weights of these materials were determined for each tree. Beaver utilize only bark and cambium from twigs and limbs larger than one-half inch in diameter, and therefore only the weight of bark removed from such branches was considered as food. Average diameter of logs at the final cut made by beaver was 3.55 inches. The bark was carefully removed and weighed to the four-inch diameter limit. Since bark on larger portions of aspen is very seldom disturbed, it was not considered as food.

Weight of limbs, branches and twigs from one-half inch to four inches was recorded; then the bark was removed from this material and weighed. Thus, a ratio was established between weight of bark and weight of unbarked limbs. In twenty-three trees in the one-inch class the weight of bark averaged 30.9 per cent of the gross weight of the limbs. Weight of the bark of ten larger trees averaged 28.5 per cent of the gross weight of the limbs. These were distributed according to diameter as follows: two 2-inch; two 3-inch; one 4-inch; two 5-inch; one 6-inch; one 8-inch; and one 9-inch. There was only 2.4 per cent difference in ratios between young and old trees. Young trees produced the most food per weight of small limbs. Relative weight of small branches and twigs in trees with large crowns increases in relation to weight of large

TABLE 2.—AVERAGE NUMBER OF ASPEN PER ACRE BY DIAMETER CLASS (IN INCHES)

| Diameter Class | 1 | 2 | 3 | 5 | 9 | 10 | 12 |
|---|---|---|---|---|---|---|---|
| Average DBH | 1.03 | 1.98 | 2.95 | 4.79 | 9.5 | 9.82 | 11.67 |
| Number on Plot | 319 | 46.7 | 45 | 21 | 8 | 22 | 15 |
| Equiv. No. per Acre | 3,190 | 467 | 450 | 210 | 80 | 220 | 150 |
| No. of Other Tree Species | 3 | 3 | 3 | 4 | 5 | 5 | 3 |
| Per cent of Stand in Aspen | 93.8 | 85.7 | 77.7 | 67.2 | 44.2 | 45.9 | 53.8 |

limbs. Weight of bark on a small twig is greater than weight of wood, while in larger limbs the wood weighs several times as much as the bark. The extreme ratio of bark to wood is demonstrated by a large-crown aspen six inches d.b.h. in which the bark weight was 51 per cent of the weight of the branches involved.

Since the sample of trees measured was representative of the condition on the area, the average ratio of 30.17 was used for all size classes in converting weight of branches (one-half inch to four inches in diameter) to weight of bark represented. The 109 trees cut, weighed, and measured were distributed according to diameter classes as shown in Table 3.

Table 3 also shows the average amount of beaver food produced per tree for each diameter class.

### PRODUCTION OF FOOD PER ACRE PER YEAR BY DIAMETER CLASSES

Yield of beaver food per acre per year is shown in Table 4. The one-inch diameter class produces over three times as much beaver food per year of growth as the two-inch class and several times as much as any other class. This strongly suggests possibilities of management.

The great reduction in numbers of trees per acre which occurs between the one-inch and the two-inch size indicates that six out of every seven trees die through natural attrition within that four-year period. Under a system of intensive management for beaver production, this thinning could be made by hand and the material fed to beaver. The same principle now applied by foresters in stand improvement cuttings would suffice. This would not only utilize the material grown but would also release the remaining stand for more rapid and better growth without the slowdown caused during the period of severe competition. This would amount to a harvest of about 85 per cent of the stand during that period and would still leave a fully stocked area.

A second pronounced reduction in numbers occurs between the three-inch and four-inch diameter classes. One-third of the number is lost in this four-year period. The percentage of aspen in the stand also drops from 85.7 in the two-inch class to 72 in the four-inch class. Under an intensive management plan both of these features could be con-

TABLE 3.—WEIGHT OF BEAVER FOOD PER TREE.

| DBH Inches | Leaves and Twigs lbs. | Bark lbs. | Total Food lbs. | No. of Trees | Average per Tree lbs. |
|---|---|---|---|---|---|
| 1..... | 51.4 | 14.2 | 65.6 | 23 | 2.85 |
| 2..... | 34.6 | 73.8 | 108.4 | 11 | 9.85 |
| 3..... | 96.8 | 228.5 | 325.3 | 14 | 23.23 |
| 4..... | 163.8 | 343.1 | 506.9 | 13 | 39.0 |
| 5..... | 318.0 | 338.1 | 656.1 | 14 | 46.86 |
| 6..... | 427.2 | 264.3 | 691.5 | 11 | 62.86 |
| 7..... | 608.7 | 305.8 | 913.6 | 11 | 83.05 |
| 8..... | 624.8 | 282.5 | 907.3 | 7 | 129.61 |
| 9..... | 278.7 | 138.6 | 417.3 | 3 | 139.1 |
| 10..... | 325.4 | 120.7 | 446.1 | 2 | 223.05 |

TABLE 4.—WEIGHT OF BEAVER FOOD PER ACRE

| DBH Inches | Number of Trees per Acre | Per cent of Stand in Aspen | Ave. Wt. of Beaver Food per Tree Lbs. | Weight of Beaver Food per Acre Lbs. | Percent Utilized | Weight Utilizable per Acre Lbs. | Age of Tree | Wt. Utilizable Food per Acre per Year of Growth Lbs. |
|---|---|---|---|---|---|---|---|---|
| 1..... | 3,190 | 93.8 | 2.85 | 9,091 | 97.8 | 8,891 | 6.6 | 1,347.1 |
| 2..... | 467 | 85.7 | 9.85 | 4,600 | 91.5 | 4,210 | 10.6 | 397.2 |
| 3..... | 450 | 77.7 | 23.23 | 10,454 | 86.0 | 8,990 | 14.6 | 615.8 |
| 4..... | 293 | 72.0 | 39.0 | 11,427 | 75.4 | 8,616 | 18.6 | 463.2 |
| 5..... | 210 | 67.2 | 46.86 | 9,841 | 69.1 | 6,800 | 22.7 | 299.6 |
| 6..... | 215 | 60.0 | 62.86 | 13,515 | 69.1 | 9,340 | 26.7 | 349.8 |
| 7..... | 200 | 50.0* | 83.05 | 16,610 | 71.3 | 11,843 | 30.7 | 385.8 |
| 8..... | 190 | 45.0 | 129.61 | 24,626 | 64.4 | 15,860 | 34.7 | 457.1 |
| 9..... | 180 | 45.0 | 139.1 | 25,038 | 64.4 | 16,124 | 38.7 | 416.6 |
| 10..... | 170 | 45.0 | 223.05 | 37,918 | 64.4 | 24,419 | 42.7 | 571.9 |

* These figures were estimated from the curve established from the rest of the data.

trolled. A harvest of 33 per cent of the remaining stand could be fed to beaver and during this harvest, the competing species could also be eliminated if that should be desirable. If some of the aspen removed in these operations were cut in the spring or early summer when sprout growth is greatest, a good young stand might result. Stands of three-inch and four-inch trees had a very open understory and therefore sprout growth might well survive.

Larger diameter classes show a gradual decline in number of trees per acre and a gradual increase in amount of beaver food utilizable per year of growth. The percentage of the stand composed of aspen gradually decreases from 72 per cent to about 45 or 50 per cent. Competing, longer-lived species gradually displace the aspen. Silvicultural practices could greatly change this situation if desirable. Quicker return to other species could be obtained or a pure stand of aspen could be maintained. The latter would be desirable for beaver production. Since management for either purpose was not applied to the areas studied, we may consider present conditions the result of normal succession.

## DEGREE OF UTILIZATION

Beaver, for several reasons, do not utilize all food produced by each tree that is cut. Some severed trees lodge in adjacent trees or fall across boulders or other obstacles which make various amounts of food inaccessible to beaver. Other trees are abandoned for reasons unknown and different amounts are left unused. Field observations indicate that the amount of waste differs in various diameter classes. In order to determine degree of utilization, close estimates were made of the percentage of food utilized on over 800 trees by diameter classes.

Table 4 summarizes the per cent of utilization by diameter classes. It shows a gradual decrease in percentage utilized by beaver, at least to the eight-inch diameter class.

## DISCUSSION

In order to properly evaluate the above findings and for the purpose of determining the most advantageous use of the areas concerned it is necessary to understand several basic factors con-

cerning both the beaver and the trees.

FOOD REQUIREMENTS OF BEAVER: Several investigators have measured the amount of aspen required daily by beaver in captivity. Conditions under which these animals were kept varied greatly; therefore, it is still difficult to state definitely their exact requirements. An average of the amounts recorded by Bradt (1947) in Michigan, Warren (1940) in Colorado, O'Brien (1938) in Maine, and Aldous (1938) in Minnesota gives a figure of 4.5 pounds per beaver per day. On this basis it seems reasonable to assume that five pounds per beaver per day certainly would be adequate. If the animals were living in the wild under intensive management and able to supplement aspen with other natural foods, which is the case on the Huntington Forest, the amount would no doubt be much less. At five pounds per day one beaver would require 1,825 pounds of aspen per year if no other foods were available and they depended upon aspen the year around.

Field observations disclose that extensive cutting of aspen is carried on only during late summer and fall. From the time the water areas open in the spring until late summer beaver feed on more succulent plants and their use of aspen is very limited. For this reason the writer believes that for at least four months of the year the beaver's food consists almost entirely of other materials. Therefore, by using the even number of 1,500 pounds of aspen per year per beaver, we actually have a considerable margin of safety.

PRODUCTIVITY OF BEAVER: Sex ratio of beaver has been found to be about 50:50. Females normally bring forth their first young on or near their third birthday. The average number of young per litter is four. Beaver normally breed once a year and remain productive for at least ten years. Young stay with the parents for two years. An established colony would thus consist of two adults, one litter of yearlings and one current season litter. If each litter consisted of four kits this would mean ten beaver in the colony. Various investigators agree that with this rate of reproduction an annual take of about one-third will maintain the population level. Actually it allows for an increase unless natural mortality is high.

VALUE OF BEAVER PELTS: The price of individual pelts in New York State has varied from a low of $8.00 in 1937 to a high of $46.00 in 1946. The average price since 1937 has been $23.09.

Buckley (1950) worked out what he called the "potential value of beaver," which is the equivalent of stumpage value for timber. It is the market value of the pelt minus the cost of harvesting. He sets cost of harvesting at $9.00 per pelt or an allowance of $1.00 per hour of the trapper's time and $1.00 depreciation on the equipment for every pelt. This seems like a very liberal figure. Accepting these figures, the potential value of pelts in New York State has averaged $14.09 since 1937.

POSSIBLE YIELD OF BEAVER PER ACRE: As far as we know, there is no true saturation point for beaver. The number per acre seems to be determined largely by available food.

VALUE OF THE AREA FOR PRODUCTION OF BEAVER FOOD: Table 4 shows that aspen stands of the one-inch d.b.h. class produced beaver food at the average rate of 1,347 pounds per acre per year. Therefore, if the entire 85 acres

occupied by beaver east of Deer Lake were covered with aspen of this size, they would produce 114,511 pounds of beaver food per year, or enough to feed 76 beaver. This would furnish an annual crop of 25 beaver each year and, at a potential value of $14.09 each, would give an income of $4.14 per acre per year. Of course, such perfection of production and control is unheard of; however, 50 per cent efficiency would still yield $2.07 per acre per year. The average age of the one-inch tree was 6.6 years, which would mean a rotation period of less than ten years, allowing two or three years for reproduction of aspen at the start.

If management were applied during the early years of the aspen stand so that trees were properly thinned, production of beaver food could be greatly increased. The low yield shown for the two-inch class would be overcome since crowns of trees would be increasing in size as space became available. Under natural conditions most of the trees are crowded out. This is further borne out by the growth in height made by trees between the one-inch and two-inch diameter classes.

Average yield for all diameter classes is 505 pounds per acre per year without management. Therefore, if the 85 acres were covered by trees of assorted sizes, they would support about 28.6 beaver per year equivalent to an annual harvest of nine beaver per year and an income of $1.49 per acre per year.

Even an extensive type of management of the entire area would cause a higher yield of the smaller stands so it seems reasonable to assume that this latter figure could be doubled at least. If this is true the returns from beaver pelts alone on the 85 acres under an extensive type of management then could be expected to be about $2.98 per acre per year.

VALUE OF THE AREA FOR THE PRODUCTION OF ASPEN AS WOOD: At present, (June, 1953) aspen has a stumpage value of $1.00 per cord in south-central New York where it is easily accessible. Much of the Adirondack region, including the Huntington Forest, is not so conveniently located, with the result that aspen has a negative stumpage value in such areas as the one under consideration. However, the amount of aspen wood produced on the area is of interest. Applying a local volume table for aspen on the Huntington Forest (Belyea, 1942) we derive the figures shown in Table 5. The site for which this volume table was constructed is better than that at Deer Lake; therefore volume of wood per acre is greater.

Aspen stands covered in this study never produce an average annual growth of one cord per acre. This rate of production of wood is in close agreement with conditions in the Lake States. Kittredge and Gevorkiantz (1929) make the statement, "The stocking of aspen in the Lake States should produce ten to 30 cords to the acre at 40 to 50 years of age."

Since the value of aspen, as wood, on the area is not great enough to pay the cost of harvesting, its justification must rest in value as food for beaver, mulch producer, soil stabilizer, and shelter for the more valuable tree species during their establishment.

VALUE OF THE AREA FOR THE PRODUCTION OF HARDWOODS: On the study area, northern hardwood is the logical successional forest type. Strong (1950)

TABLE 5.—VOLUME OF ASPEN WOOD PER ACRE

| DBH Inches | Vol. per Tree Cu. Ft. | Trees per Acre | Volume per Acre Cu. Ft. | Volume per Acre Cords | Age of Trees | Wood per Yr. Cords |
|---|---|---|---|---|---|---|
| 2..... | .09 | 467 | 42.03 | .467 | 10.6 | .044 |
| 3..... | .02 | 450 | 9.00 | .100 | 14.6 | .068 |
| 4..... | .09 | 293 | 26.37 | .293 | 18.6 | .102 |
| 5..... | 1.9 | 210 | 399.0 | 4.43 | 22.7 | .195 |
| 6..... | 3.7 | 215 | 795.5 | 8.84 | 26.7 | .331 |
| 7..... | 6.4 | 200 | 1,280.0 | 14.22 | 30.7 | .463 |
| 8..... | 9.4 | 190 | 1,786.0 | 19.84 | 34.7 | .572 |
| 9..... | 12.8 | 180 | 2,304.0 | 25.60 | 38.7 | .661 |
| 10..... | 16.5 | 170 | 2,805.0 | 31.17 | 42.7 | .730 |
| 11..... | 21.1 | 160 | 3,376.0 | 37.51 | 46.8 | .801 |
| 12..... | 26.4 | 150 | 3,960.0 | 40.00 | 50.8 | .787 |

states: "The Hardwood and Hardwood Conifer types on the Huntington Forest could support an annual growth of about 200 board feet per acre under management." Buckley (1950) quotes the stumpage value for this area at $10.33 per thousand. This would mean that the production of 200 board feet per year would have a stumpage value of $2.07 per acre per year.

## CONCLUSIONS

The foregoing information is of value in considering the best land use of that part of the Huntington Forest now covered with aspen and bracken fern. The area extending about 250 feet from the water's edge of beaver ponds may be considered potential beaver territory because the animals normally do not range beyond that distance. Greatest monetary returns per acre per year for the aspen stand has been shown to be in beaver pelts. The value of aspen as wood is negative in this area. Even the yield of hardwoods which might eventually displace aspen has an annual return below that of beaver. The greatest yield of beaver food per year is from very young trees, to the one-inch d.b.h. size. This size is reached in about six years.

A management plan for aspen areas should be designed to assist replacement of aspen by conifers and hardwoods in areas beyond beaver range and should assist regeneration and perpetuation of aspen in areas available to beaver. Emphasis should be placed upon production of small trees.

Beaver is a crop which is harvestable annually while timber requires at least 50 years, and much longer after an area has been burned. If beaver should be wiped out, or a second fire destroy the area, it could be in production again in a few years.

Beaver is not the only wildlife species associated with aspen stands. Grouse, deer, varying hare and fox must also be included. Each of these species adds to the wildlife value of the area. The four species mentioned are the favored ones from the sportsman's standpoint.

Deer and varying hare use aspen as food and are associated with aspen stands. An abundance of available aspen

may cause an increase in deer population. This species alone adds considerably to the value of the area.

When other species associated with beaver ponds such as fish, ducks, raccoons, mink, otter and muskrat are considered, economic potential is greatly increased. The furbearers would be present around water areas in any event; however, increased amounts of food for these species resulting from formation of beaver ponds increases the numbers of these animals.

It is the writer's opinion that the combined economic value of increased associated species, which are added to an area because of the presence of beaver, is equal to or even greater than that of the beaver itself.

King (1947) lists six different kinds of values possessed by wildlife which apply to aspen areas of the Huntington Forest. However, because of the remote location of the area under consideration only the commercial value has been emphasized.

## SUMMARY

1. The area studied is typical of much of the Adirondack region and the findings should be applicable over a wide area.

2. Average annual rate of growth of aspen on the Huntington Forest for the first inch in diameter is .15 inch and for all larger trees is .249 inch.

3. Amount of utilizable beaver food per acre represented by aspen stands of one inch diameter was 8,891.5 pounds. Average amount of beaver food per acre represented by aspen of all diameters was 11,510 pounds.

4. Average amount of utilizable beaver food produced per acre per year of growth was 1,347 pounds for the one-inch diameter class. Average amount of utilizable beaver food produced per acre per year of growth for all diameters was 530 pounds.

5. Size of aspen producing the greatest amount of beaver food per acre per year was the one-inch diameter class which averaged 6.6 years of age.

6. Degree of utilization of aspen by beaver decreases from 97.8 per cent for the one-inch diameter class to 64.4 per cent in the 8-inch and larger diameter classes.

7. The most advantageous rotation period for aspen for production of beaver food would be about ten years.

8. Commercial value of the study area for the production of aspen as wood was nil. Commercial value of the study area for production of hardwoods was about $2.07 per acre per year under management. Commercial value of the study area under an extensive type of management for production of beaver pelts was about $2.98 per acre per year. If managed for beaver production, the area would produce other commercial and biological values at the same time which are believed to be in excess of the value of beaver pelts.

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# AGE AND GROWTH OF THE BLUEGILL, *Lepomis m. macrochirus* (RAFINESQUE), IN A NEW MISSOURI IMPOUNDMENT[1]

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Changes in fish populations occur frequently with aging of a reservoir. In some instances, fish such as bass and bluegill, which are common in the first few years of reservoir fishing, decline and tend to be replaced in the creel by crappie or some other species. This study of the northern bluegill, *Lepomis macrochirus macrochirus* (Rafinesque), was designed to follow the growth rate of a developing population of this popular sport fish during the first four years of a new reservoir and to contribute to our understanding of population dynamics in this environment.

Clearwater Lake is a typical flood-control reservoir formed in 1948 by damming the Black River. It is located in southeastern Missouri, in parts of Wayne and Reynolds Counties, in the Ozark Highland. At conservation pool level the lake covers 1,650 acres, and at spillway crest, 73 feet above this, it would include approximately 10,350 acres. The reservoir is shallow with a maximum depth not exceeding 50 feet at conservation pool level. The water level in the lake is maintained by a constant flow from Black River and tributary creeks. Flash floods may raise

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri cooperating.

The writer is grateful to Dr. Robert S. Campbell, University of Missouri, for direction of the research; the Missouri Conservation Commission, Fisheries Section, for field data; Mr. Hudson M. Nichols for aid in the field; and Mr. James Bobo of the Army Corps of Engineers for permission to use the study area.

the level of the lake as much as four feet during a 24-hour period.

Standard procedures were used throughout this study. Methods of collection included angling, netting, seining and the use of rotenone. Total length and weight measurements were from fresh specimens. A series of standard length measurements was employed to develop the conversion factor:

$$\text{Standard length} = \text{total length} \times 0.782.$$

Data for age composition were gathered by personnel of the Missouri Conservation Commission during 9 days of intensive netting in late October of 1949, 1950, 1951, and 1952. Equal numbers of netting hours were maintained for each year with the exception of 1952 when two additional nets were used. Equipment consisted of hoop, gill, and trap nets. It is recognized that these nets were selective in their catch but they did sample effectively fish of the size that appeared in the creel.

Key scales were not used in this study, but several scales were removed from a key area, just below the lateral line and in line with the first dorsal spine. Impressions of four scales from each fish were made in plastic sheets (Campbell and Witt, 1953) and examined under a microprojector. Radial measurements along the anterior median line were read from the largest scale image ($\times$ 50) from each fish.

Back-calculations of the growth histories were derived with the use of a nomograph modified after Carlander and Smith (1944).

The length-weight relationship was calculated as described by Beckman (1948), but with slight modifications.

In calculating the body-scale relationship, total lengths of 797 fish were grouped in half-inch intervals and the mean of each interval was plotted against the mean of the corresponding length of the anterior scale radius $\times$ 50.

A line representing the body-scale relationship (Fig. 1) was fitted to these points by calculation. The equation for the straight line was:

$$Y = -0.892 + 1.085X.$$

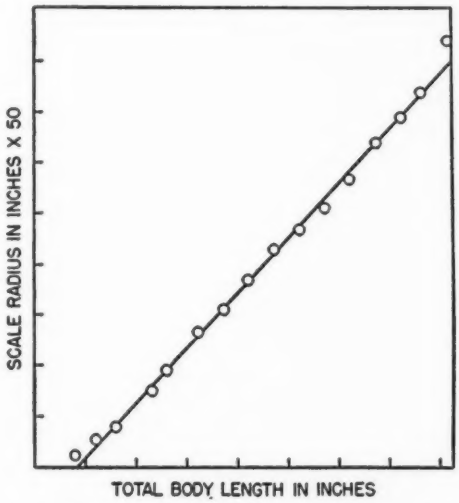


FIG. 1. The body-scale relationship exhibited by 797 bluegill from Clearwater Lake, Missouri. The equation of the line is $Y = -0.892 + 1.085\ X$.

The coefficient of correlation was used as a measure of fitness and was found to be +.995. The intercept was at 0.82 of an inch.

Analysis of the netting records for the four-year period, 1949 through 1952 (Table 1) shows that the 1948 year class was dominant in the catch for each year including 1952. This 1948 year class was the first spawned in the new reservoir.

TABLE 1.—PERCENTAGE OF OCCURRENCE OF EACH YEAR CLASS IN THE CATCH OF BLUEGILL FROM FALL NETTING, 1949 THROUGH 1952, CLEARWATER LAKE, MISSOURI

| Year Class | Percentage of the catch of bluegill belonging to each year class for the year | | | |
|---|---|---|---|---|
| | 1949 | 1950 | 1951 | 1952 |
| 1947 | 9 | 8 | .... | 2 |
| 1948 | 91 | 83 | 59 | 53 |
| 1949 | .... | 9 | 16 | 12 |
| 1950 | .... | .... | 24 | 19 |
| 1951 | .... | .... | 1 | 14 |
| Size of sample aged | 143 | 52 | 80 | 130 |
| Total catch of bluegill | 147 | 179 | 99 | 130 |
| Percentage of bluegill in catch | 19.1 | 17.8 | 14.9 | 11.8 |

The relative abundance of young bluegill in the small-fish population in 1948 and in other years was: 1947, 0.1 per cent; 1948, 17.8 per cent; 1949, 47.0 per cent; and 1950, 10.0 per cent (Martin and Campbell, 1953). The survival rate for the 1948 brood must have been unusually high to have permitted their continued abundance in the creel.

The 1949 year class, although abundant as young of the year, was not taken in abundance by the nets in 1950, 1951 or 1952. The 1950 year class was stronger in both the 1951 and 1952 catch than was the 1949 year class.

The 1947 year class which had existed in the river prior to impoundment, was not used in growth calculations. Their importance lay in the fact that they were the stock from which the population in the reservoir developed.

The calculated growth history for the first four year classes (1948 through 1951) from Clearwater Lake and for the 1947 year class from Black River is presented in Table 2. The grand average length for each year of life along with the increment of growth for each year is given also. The 854 fish used in these calculations were of both sexes. The 1947 year class is presented for comparison; however, these fish were spawned in the river and were not included in the calculations of the grand average lengths and the average increments of growth. The grand average lengths and the average increments of growth were determined from individual records and not from computations using age group averages.

TABLE 2.—AVERAGE TOTAL LENGTH (INCHES) FOR EACH AGE GROUP ARRANGED BY YEAR CLASSES FOR BLUEGILL FROM CLEARWATER LAKE, MISSOURI, 1948 THROUGH 1951, AND FROM BLACK RIVER, MISSOURI, 1947. FIGURES IN PARENTHESES ARE NUMBER OF FISH

| Year Class | Average total length for age group | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| 1947 | 1.9 (24) | 4.6 (24) | 6.0 (11) | 6.9 (7) |
| 1948 | 2.8 (555) | 4.2 (425) | 5.6 (373) | 6.6 (293) |
| 1949 | 2.5 (80) | 4.1 (75) | 5.5 (59) | ..... |
| 1950 | 1.8 (101) | 4.0 (36) | ..... | ..... |
| 1951 | 1.7 (94) | ..... | ..... | ..... |
| Average length | 2.5 | 4.2 | 5.6 | 6.6 |
| Average increment | 2.5 | 1.7 | 1.5 | 1.1 |

Analysis of the data in Table 2 shows that there was a small consistent decline in the rate of growth of the Clearwater Lake bluegill population, 1948 through 1951, when year classes were compared within any age group. This is interpreted as an expression of diminishing growth rates for each successive year from 1948 through 1951.

The differential growth exhibited between sexes is based upon examination of 375 fish (Table 3). Of these, over 60

TABLE 3.—THE AVERAGE TOTAL LENGTH (INCHES) FOR EACH AGE GROUP OF MALE AND FEMALE BLUEGILL FROM CLEARWATER LAKE, MISSOURI, 1949 THROUGH 1952. FIGURES IN PARENTHESES ARE NUMBER OF FISH

| | Average total length of age group | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| Males..... | 3.1 (242) | 4.6 (170) | 6.0 (141) | 7.0 (113) |
| Females.... | 2.9 (133) | 4.1 (67) | 5.4 (47) | 5.9 (17) |

per cent were captured by angling. Male bluegill outgrew the females in each age group in Clearwater Lake, 1949-1952. It may be noted that the average length of each age group in Table 3 is greater than the calculated average lengths for comparable age groups based on 830 fish collected by netting, seining, poisoning and a limited amount of angling (Table 2). These greater average values in Table 3 are thought to be due to the selective capture of larger fish through angling.

The growth rate of young-of-the-year bluegill was learned from seine collections spaced throughout the summer of 1952. Young of the year first appeared in seine collections on July 7. At that time the average length of 67 fish was 0.85 inches. The next sample of 77 individuals, taken on July 27, averaged 1.3 inches in length. On September 17, the average length of 58 young-of-the-year bluegill was 1.7 inches. This length approaches the average length of the age group I bluegill from the 1951 year class (Table 2) and suggests that the growing season in 1952 extended to the latter part of September.

The time of annulus formation was determined from scales of 560 fish of the 1952 collection (Table 4). The annulus had appeared on the scales of all three- and four-year-old fish by the first of September. In all two-year-old fish the annulus had appeared by the first week in July, and in all the yearlings by June first. This sample of the population shows that there was a time differential of three months between the appearance of the annulus on scales of most yearlings and on scales of most fish of age group IV.

The length-weight relationship was developed from 663 bluegill taken from Clearwater Lake, 1949 through 1952.

The relationship was expressed by the formula:

$$\log W = -0.7375 + 3.306 \log L$$

where W = weight in grams and L = total length in inches. The length and weight data used in developing the above relationship are shown in Table 5. There was good agreement between the empirical weights and calculated weights. With the exception of the four largest fish, the greatest discrepancy was approximately 5 grams.

TABLE 4.—THE PERCENTAGE FREQUENCY OF 1952 ANNULI ON SCALES OF 560 BLUEGILL FROM CLEARWATER LAKE, MAY THROUGH OCTOBER. FIGURES IN PARENTHESES ARE NUMBER OF FISH

| Age group | Percentage frequency of 1952 annuli in | | | | | |
|---|---|---|---|---|---|---|
| | May | June | July | August | September | October |
| IV ..... | 6 (106) | 17 (18) | 27 (30) | 77 (64) | 100 (6) | 100 (70) |
| III ..... | 29 (24) | 100 (2) | 50 (4) | 75 (12) | 100 (1) | 100 (16) |
| II ..... | 0 (2) | ..... | 100 (1) | 100 (7) | 100 (1) | 100 (25) |
| I ..... | 71 (17) | 100 (42) | 94 (32) | 100 (2) | 100 (61) | 100 (18) |

TABLE 5.—AVERAGE TOTAL LENGTH (INCHES) AND WEIGHT (GRAMS) USED FOR THE CALCULATION OF THE LENGTH-WEIGHT RELATIONSHIP OF 663 BLUEGILL COLLECTED IN CLEARWATER LAKE, MISSOURI, 1949 TO 1952

| Number of fish | Total length | | Weight | | |
|---|---|---|---|---|---|
| | Length interval | inches | grams empirical | grams calculated | ounces calculated |
| 1 | 2.5–2.9 | 2.7 | 6 | 6.2 | 0.2 |
| 16 | 3.0–3.4 | 3.2 | 8 | 8.2 | 0.3 |
| 25 | 3.5–3.9 | 3.7 | 13 | 13.7 | 0.5 |
| 50 | 4.0–4.4 | 4.2 | 23 | 21.0 | 0.7 |
| 41 | 4.5–4.9 | 4.7 | 33 | 30.7 | 1.1 |
| 72 | 5.0–5.4 | 5.2 | 40 | 41.8 | 1.5 |
| 62 | 5.5–5.9 | 5.7 | 58 | 56.7 | 2.0 |
| 58 | 6.0–6.4 | 6.2 | 76 | 75.0 | 2.7 |
| 116 | 6.5–6.9 | 6.7 | 105 | 99.5 | 3.5 |
| 163 | 7.0–7.4 | 7.2 | 125 | 123.7 | 4.4 |
| 55 | 7.5–7.9 | 7.6 | 153 | 150.7 | 5.3 |
| 4 | 8.0–8.4 | 8.2 | 181 | 192.1 | 6.8 |

Gonad development was observed in 125 males and 20 females large enough to spawn from the 1952 collection. The spawning period for bluegill in Clearwater Lake extended from June to September in 1952. The first record of males in spawning condition (designated as ripe) occurred during the first week in June. By the second week in June, 40 per cent of the captured males taken were ripe. During the second week of July, 72 per cent were ripe and the peak was reached between the third week of July and the first week of August during which time 99 per cent of the males examined were ripe.

The first spent males were seen during the fourth week of July. During the second week of August, 28 per cent were spent and by the second week of September, all of those examined were spent.

The females exhibited a similar pattern, however, sample size was inadequate for detailed analysis.

Morning water temperatures, recorded at a depth of 32 inches, reached 80°F. during the first week of June. The water temperature remained between 80°F. and 90°F. until the third week of August and above 74°F. through the second week of September.

Records of sexual maturity were available from 249 bluegill of all sizes. Analysis of these data (Table 6) shows that sexual maturity is a function of both age and body length. Most fish over 4.5

TABLE 6.—THE RELATIONSHIP OF SEXUAL MATURITY TO TOTAL LENGTH AND TO AGE IN 249 BLUEGILL FROM CLEARWATER LAKE, MISSOURI, 1949 TO 1952. FIGURES IN PARENTHESES ARE NUMBER OF FISH

| Total length interval in inches | Percent sexually mature fish | Age group | Percent sexually mature fish |
|---|---|---|---|
| 3.0–3.4 | 0 (5) | | |
| 3.5–3.9 | 0 (16) | I | 2 (95) |
| 4.0–4.4 | 0 (25) | | |
| 4.5–4.9 | 85 (13) | II | 70 (37) |
| 5.0–5.4 | 75 (16) | | |
| 5.5–5.9 | 95 (19) | III | 88 (17) |
| 6.0–6.4 | 86 (21) | | |
| 6.5–6.9 | 100 (53) | IV | 100 (100) |
| 7.0– + | 100 (81) | | |

inches in total length were mature. It was found that 70 per cent of the bluegill of age group II were mature. An insufficient sample may have been responsible for the relatively low percentage of mature fish from age group III.

## DISCUSSION

Those concerned with reservoir management and bluegill populations will be interested in the declining growth rate herein described for the bluegill during the first four years of impoundment of Clearwater Lake. A similar declining growth rate was reported for bluegill during the first two years of growth in the new Canton Reservoir, Oklahoma (Buck and Cross, 1951). The growth records from Meander Lake, Ohio (Roach, 1949) show better growth rates in the early history of the reservoir.

Among the factors that were responsible for this declining growth rate as the reservoir aged, the following are worthy of special note: (1) a habitat less favorable for growth than that when the reservoir first filled due to a restricted food supply; (2) delayed nesting in 1950 and 1951 due to fluctuating water levels; and (3) an increase in population density of fishes.

An increase in the number of fishes would be expected while the population was developing to the carrying capacity of the lake. This was evident in the relative abundance of bluegill in small-fish collections from 1947 through 1950. The decline of bluegill in 1950 did not reflect a general decrease in total number of fishes but rather was well compensated for by an exceptional increase in gizzard shad.

Terrestrial insects and other invertebrate foods were unusually abundant in the newly inundated shoals in 1948, and, within one month of impoundment there had developed a substantial benthos (O'Connell and Campbell, 1953). In subsequent years, in the absence of an abundance of terrestrial invertebrates, the relatively stable benthos had to supply an increasing population of bluegill and other bottom-feeding species. Any limitation in food supply would be reflected in a diminishing rate of growth.

Fluctuations in water level as great as 35 feet during the early part of the spawning season in 1950 and in 1951 are considered to have delayed successful spawning. From June 12 to July 18, 1950, the water dropped approximately one foot per day. With nest destruction the average increment of growth in the first year for the 1950 and 1951 year classes would not be as great as the growth increment for the young-of-the-year of 1948 and 1949 when early nesting was not impaired by pronounced changes in water level.

A comparison of the average total lengths at the end of each year of life of Clearwater Lake bluegill with lengths of bluegill from other reservoirs and natural lakes is shown in Table 7. These limited data suggest that the growth rate of bluegill in Clearwater reservoir is about average when compared to the rate of growth in other new impoundments, and better than the growth rate in most of the natural lakes listed.

The spawning period of bluegill in Clearwater Lake was similar to that in Fork Lake, Illinois (Bennett, Thompson, Parr, 1940). Some bluegill were sexually mature in their second summer of life in both Clearwater and Fork lakes.

The annulus appeared in yearling fish

TABLE 7.—AVERAGE CALCULATED LENGTH (INCHES) FOR EACH AGE GROUP OF BLUEGILL FROM SEVERAL RESERVOIRS AND SEVERAL NATURAL LAKES

| Nature of water | State | Author | Average total length in inches for age group | | | |
|---|---|---|---|---|---|---|
| | | | I | II | III | IV |
| Clearwater reservoir | Missouri | | 2.5 | 4.2 | 5.6 | 6.6 |
| 14-year-old reservoir | Ohio | Roach, 1949 | 1.3 | 3.0 | 4.5 | 5.7 |
| 8-year-old reservoir | Illinois | Bennett, 1945 | 1.8 | 4.8 | 6.4 | 7.4 |
| 3-year-old reservoir | Tennessee | Eschmeyer, Stroud, Jones, 1944 | 2.0 | 4.8 | ... | ... |
| Reservoir | Illinois | Bennett, Thompson, Parr, 1940 | 2.8 | 4.5 | 5.3 | 5.6 |
| 4-year-old reservoir | Tennessee | Eschmeyer, 1940 | 3.1 | 3.7 | 4.5 | 4.9 |
| 5-year-old reservoir | Ohio | Roach, 1949 | 4.0 | 5.2 | 6.6 | ... |
| 3-year-old reservoir | Oklahoma | Buck and Cross, 1951 | 4.1[1] | 4.9 | 6.1[2] | ... |
| 5 natural lakes | Illinois | Bennett, 1945 | 1.3 | 3.5 | 4.9 | 6.0 |
| Natural lake | Iowa | Lewis, 1950 | 1.4 | 3.4 | 6.1 | 7.2 |
| 56 natural lakes | Indiana | Ricker, 1942 (from Carlander, 1950) | 1.5 | 3.0 | 4.8 | 6.5 |
| Natural lake | Indiana | Ricker, 1942 | 2.0 | 4.5 | 6.9 | ... |

[1] Growth of first year class in new impoundment.
[2] Actual growth to August 10.

at the same time in both Clearwater and Fork lakes; and in breeder bluegill the annulus did not appear on all scales until September and October.

The findings of this study have some implication for management of the bluegill of Clearwater Lake. It is believed that both creel and size limit restrictions are unnecessary for continuing production of the Clearwater Lake population. The average size of bluegill taken by angling during this study was 7 inches, total length. Age and maturity findings show that most fish creeled have spawned at least once and in a large percent of the cases, twice.

## SUMMARY

This study describes age and growth of a developing population of bluegill in a new flood-control reservoir. It is based on 1,496 bluegill collected from Clearwater Lake, Missouri, from 1949, the year following impoundment, to 1952.

A decreasing rate of growth was found for successive year classes, 1949, 1950 and 1951 within any one age group. This decreasing growth rate within a developing population was explained in terms of an increasing population of bluegill and other species of fishes; a restricted food supply; and delayed nesting due to fluctuating water levels.

The body-scale relationship was found to be the straight line, $Y = -0.892 + 1.085X$. The intersect was at 0.82 of an inch.

The 1948 year class, which represented the first spawn in the reservoir, was dominant in the catch for each of the 4 years studied.

The average length of male bluegill exceeded the average length of female bluegill of the same age.

The formation of an annulus was apparent on the scales of all yearling bluegill by June 1. It did not appear on scales of all 4-year-old fish until September 1.

The length-weight relationship was

expressed by the formula:

$$\log W = -0.7375 + 3.306 \log L.$$

Where W = weight in grams and L = total length in inches. The average weights for 3-, 5- and 7-inch bluegill were 0.2, 1.3 and 4.0 ounces, respectively.

The spawning season extended from June 1 into September during the summer of 1952. No fish under 4.5 inches total length was found to be sexually mature.

The growth rate of the population of bluegill in Clearwater Lake is compared with that of bluegill in certain other reservoirs and natural lakes.

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# A SHORT ACCURATE METHOD FOR ESTIMATING THE VOLUME OF STREAM FLOW[1]

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Volume of stream flow is one of the factors generally included in describing a collecting or study station on a stream. The method in general use for estimating volume of stream flow was described by Embody (1927, pp. 3-4). A new method which yields more or equally accurate estimates with less time and effort is described here.

Experiences of the authors have shown that different individuals estimating flow at a given locality under similar conditions often obtain very different results. Comparison of such estimates made by members of the same parties showed differences ranging from 20 to 125 cfs at one station and 25 to 80 cfs at another. Such large discrepancies were common. While some of these were rough estimates hurriedly taken, it is probable that they are typical of the estimates made by many field biologists.

Estimates of stream flow are of value in every phase of aquatic biology, but any measurement of stream flow is of value in describing local conditions only if it is accurate. This is especially true when comparing data for a particular locality from one season to the next or over a period of years. At the same time such data must be obtained quickly because time is usually a critical factor.

Embody (*op. cit.*, pp. 3-4), gives the following formula for estimating stream flow:

$$R = \frac{W\ D\ a\ L}{T} \qquad (1)$$

Where R = stream flow in cubic feet per second (cfs)
W = average width in feet over the section measured
D = average depth in feet over the section measured
L = length of section measured (commonly 100 feet)
T = time (average) for a float to traverse L (thus the current). Lagler (1952, p. 252) and Welch (1948, p. 153) state that three trials should be made to determine T.
a = constant; 0.8 if the bottom is rough (rocks and coarse gravel), 0.9 if the bottom is smooth (mud, sand, hardpan, or bedrock), (Embody, *op. cit.*, p. 4).

The method described by Embody has many shortcomings. It involves considerable time and the degree of accuracy attained is in doubt because of the number of factors estimated. The actual measuring involved may be very accurate but averaging of these measurements to determine width and depth for

[1] We are indebted to Professors John C. Ayers, David C. Chandler, Karl F. Lagler and Edward C. Raney for advice concerning the manuscript and to Professor M. Bogema for use of the Gurley current meter. The field work was supported by a New York State Honorarium Grant which the senior author gratefully acknowledges.

the whole section, and difficulties involved in obtaining T tend to make the final result only a rough estimate except under the best of conditions.

The method which we propose is a modification of that given by Welch (*op. cit.*, p. 153) for use with current meters. It is our belief that this method can be used in estimating stream flow by substituting a particular kind of float for the current meters and accurately measuring the time required to traverse a known distance.

The method is based on the fact that the total volume of water flowing in a stream flows through every cross-section. Where unchanged by tributary or spring inflows, this volume is constant. A single carefully selected cross-section where depth and current are most uniform is used. Such a section is much more easily found than is a uniform stretch of stream and may be found when a stream is blocked with ice.

The width factor W is accurate since only one measurement is required. The width is then divided into three equal segments which may be set apart by various means. In our study we have colored the surfaces of stones on rocky bottoms and have pushed sticks into mud or soft bottoms but other markers may be devised. A depth and a current reading are then taken in the center of each of the three segments.

The surface velocity V is determined by dropping a float fastened to five feet of limp monofilament nylon fishing line (.005-.01 inch diameter). Any small fisherman's float without projecting arms is suitable. The time required to travel the five feet is obtained by a stop watch and the average figure recorded and converted into feet per second.

Volume of flow R in each segment of the cross-section is determined by the following formula:

$$R = W D a V \qquad (2)$$

Where a = a bottom factor constant {see Formula (1)}
W = width of segment
D = depth taken at midpoint of segment
V = surface current velocity, taken at midpoint of segment.

Total flow is found by adding the flows for the three segments.

Sections where two streams flow together were chosen as sites for comparison of our method and the one described by Embody. Flow determinations were made on each creek just above the point of juncture and then on the combined stream immediately below the junction. By adding the flows of the component stream a predicted value for the combined flow was obtained, which could be compared with the observed combined flow. In this manner we could compare not only the methods at one location but also check the consistency of each method.

In addition, determinations at middepths were made by a Gurley current meter (Model No. 536) to serve as a control in determining V in Formula (2).

The data obtained along an area of Cascadilla Creek near Ithaca, New York, on April 8, 1953, are listed in Table 1. Here Station 1 is on Cascadilla Creek, Station 2 on a tributary and Station 3 on the combined stream just below the point of juncture.

In Table 1 the greatest volume of flow was indicated to be at Station 1 by our method and the one described

TABLE 1.—VOLUME OF FLOW, IN CUBIC FEET PER SECOND, IN CASCADILLA CREEK NEAR ITHACA, NEW YORK, APRIL 8, 1953

| | Method | | |
|---|---|---|---|
| | Embody | Float | Current Meter |
| Station 1 | 4.5 | 5.5 | 3.3 |
| Station 2 | 3.4 | 3.4 | 4.3 |
| Σ Stations 1 & 2 | 7.9 | 8.9 | 7.6 |
| Station 3 | 5.9 | 7.8 | 7.9 |

Embody whereas the current meter indicated a greater flow at Station 2. This discrepancy may be explained since the single cross-section for Station 1 was chosen on a bridge apron where the maximum depth of 0.2 feet allowed float readings but was not sufficient to allow the current meter to run properly.

To check this, another set of determinations was made on May 7, 1953 using the same stations but avoiding the apron at the bridge. These data are presented in Table 2. Again our method

TABLE 2.—VOLUME OF FLOW, IN CUBIC FEET PER SECOND, IN CASCADILLA CREEK NEAR ITHACA, NEW YORK, MAY 7, 1953

| | Method | | |
|---|---|---|---|
| | Embody | Float | Current Meter |
| Station 1 | 3.5 | 8.1 | 5.9 |
| Station 2 | 4.8 | 6.4 | 5.6 |
| Σ Station 1 + 2 | 8.3 | 14.5 | 11.5 |
| Station 3 | 8.8 | 12.0 | 11.0 |

and general observation showed the greater volume of flow to be at Station 1. With the current meter working properly, a similar conclusion was reached. Higher flows than those listed in Table 1 were caused by rains preceding the measurements. Determinations with the method described by Embody failed to show correctly either the larger stream or the increase in flow (Stations 1 and 2, Tables 1 and 2).

A similar set of data collected on a tributary to Fall Creek near Ithaca on May 6, 1953, is listed in Table 3.

TABLE 3.—VOLUME OF FLOW, IN CUBIC FEET PER SECOND, IN A TRIBUTARY TO FALL CREEK NEAR ITHACA, NEW YORK, MAY 6, 1953

| | Method | | |
|---|---|---|---|
| | Embody | Float | Current Meter |
| Station 1 | 15.0 | 10.9 | 10.1 |
| Station 2 | 2.7 | 2.1 | 2.3 |
| Σ Stations 1 + 2 | 17.7 | 13.0 | 12.4 |
| Station 3 | 15.5 | 11.4 | 11.1 |

In this situation a fifty-foot length of stream had to be employed in the determinations by the method described by Embody because of the abundance of obstacles which stopped the float.

A high degree of correlation is to be noted between the data from our method and those from the current meter readings. Readings from the third method (Embody) varied from high to low.

Current meters are usually troublesome to use and not readily available to most workers. The float method appears to give reasonable, consistent and accurate results in all stream situations with flows as high as 150 cfs. Its value on larger streams must be verified although a current-pole method similar to this has been employed on large rivers by the U. S. Coast and Geodetic Survey (Marmer, 1935, pp. 94-95). The float method, herein described, involves one width measurement, three depth measurements and the timing of a float at three places. A stop watch is the only

special equipment needed. Determinations are usually made within a few minutes. Individual judgment is involved only in the selection of a single cross-section and data collected by different workers should be comparable.

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# NEWS AND NOTES

Dr. Carlton Herman has suggested that authors of papers for journal publication read two articles in *Science*, Vol. 19, No. 3095, April 23, 1954: H. R. Struck's "Recommended Diet for Padded Writing," and E. S. McCartney's "Does Writing Make an Exact Man?" In the same issue is a series of short papers, comprising a "Conference on Scientific Editorial Problems."

We urge all authors, and others interested in THE JOURNAL OF WILDLIFE MANAGEMENT to read these papers, which total only seventeen pages. The first two, particularly, illuminate the question, "How much editing should an editor do?"

We believe that editorial responsibility includes elimination of padding and correction of obvious errors in grammar and English usage as well as typographical ones. Yet many editors of scientific journals can devote only "spare" time to the job. Also, they hesitate to work a paper over too severely because an author may be annoyed, a good paper may be delayed or lost to a journal, or a society may even lose a member! And no editor wants to be a re-write man.

In a recent review, a paper which we handled was criticized as padded. We wish the reviewer had seen the original manuscript—apparently an unabridged thesis. We spent hours on it. An alternative would have been to return it with the suggestion that the author cut it down to half its length. But the cutting down is more difficult than the writing.

While an author may love his brain-child, he hates to see it come back home. However, it is well to remember that familiarity often conceals flaws.

The solution to this vexing problem is not difficult. No matter how experienced an author may be, his work will benefit by every critical reading it receives by his colleagues.

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New York is to be congratulated on the recent publication of the first of a new technical series—the *New York Fish and Game Journal*.

The initial issue, comprising 117 pages, contains eight major papers and one short note, with subject matter equally divided between the fields of fisheries and game management. The size, $5\frac{1}{2}''$ x $8\frac{1}{2}''$, is convenient and format pleasing.

From the back cover: "The *New York Fish and Game Journal* is devoted to presenting the results of research and management studies in New York and other technical papers on related subjects. It is published semi-annually and is distributed free to official conservation agencies and scientific institutions. It is also furnished free to selected libraries and conservation organizations in New York State. Others may subscribe at a rate of $1.50 per year or obtain individual issues for 75c per copy. Correspondence should be addressed to the Editor: Robert W. Darrow, New York Conservation Department, Albany 1, New York."

# THE WILDLIFE SOCIETY

## Report of the Executive Secretary for the Year 1953-54

### Secretarial Account

The Society's fiscal year 1953-54 was the first in which the duties of Secretary and Treasurer were combined in the Office of Executive Secretary. Dr. George A. Petrides, appointed to this office by last year's Council, resigned on August 20, 1953, to accept a Fulbright Fellowship in Kenya for a study of big game. The incumbent, having had a part in setting up the office, offered the services of himself and his wife if the Council found it difficult to fill the post during the short time before George's resignation. Very shortly thereafter the "Exec" and "Secretary" came to the conclusion that life among the Mau Maus must be much simpler and less confusing than that which they were facing.

From August 20 until February 28, my wife, as clerical assistant, worked a minimum of 306 hours and I worked a minimum of 399 hours at home on Wildlife Society business. This does not include trips to and from the bank and printing or stationery shops. It also excludes work done on the Society Employment Committee and any time spent at the office on Society affairs by me or my secretary. I give these facts not in the nature of a complaint, but as an indication of the amount of work involved.

Secretarial duties consisted primarily in processing new memberships, membership renewals and subscriptions; placing orders with the printer for current and back issues of the Journal; making changes of address for members, sending invoices to subscribers; sending out ballots and dues notices; distributing membership application blanks and otherwise working with the Membership Committee; answering requests for information and handling numerous other miscellaneous details.

Your Executive Secretary represented the Society at the annual meeting of the Natural Resources Council of America, the Mid-Century Conference on Resources for the Future, the Northeast Wildlife Conference and the Southeast Conference, the latter, only, at Society expense and while on annual leave.

The Society continued to grow, having 13 Honorary, 10 Life and 2140 Annual Members and 377 Subscribers in 1953 compared with 11 Honorary, 10 Life and 1919 Annual Members and 388 Subscribers during 1952. Since January, we have had an increase of 3 new Life Members. The 510 (1952) Members who had not paid their 1953 dues as of February 28, 1953, had been reduced to 197 by February 24, 1954. Included among the 197 delinquents were several members of long standing. This number (197) materially reduced the net gain of Members even though 374 new Members joined the Society in 1953.

By February 24, 1954, a total of 240 new 1954 Members had joined the Society and the applications of 7 additional newcomers were being processed at the close of the fiscal year.

Although two 1954 dues notices had been distributed by the end of January, both of them were included with ballots or other material in an effort to economize and, apparently, many Members failed to heed them as more than 1000 Members had not yet paid their 1954 dues by March 1.

The death of four Members is regretfully reported. The deceased are: Charles C. Deam, well known Indiana botanist; Samuel N. Gangwer, also of Indiana; and Donald E. Johnson and Ray S. Meschkat of Nevada, both of whom lost their lives in a plane crash. Notices of these deaths have been conveyed to the Committee on Memorials. Members are urged to report other deaths that may not have been brought to our attention.

Mail balloting for nomination of Regional Representatives resulted as follows: Region I—Roger Latham and Roger Seamans; Region II—Leonard Foote and Eugene Wallace; Region III—Thomas R. Evans and Donald W. Douglass (Tom declined nomination but would have been replaced on the ballot because he was nominated for Vice-President. Thus the two nominees for Region III became Donald W. Douglass and S. C. Whitlock); Region IV—Lee E. Yeager and Ralph Hill; Region V—Fred Baumgartner and Wendell Swank; Region VI—A. S. Leopold and J. B. Lauckhart, becoming J. B. Lauckhart and J. B. Low with Leopold as nominee for President; and Region VII—C. David Fowle and Ian McT. Cowan.

These nominees for Regional Representatives were placed on the election ballot, together with nominees for office selected by the Nominating Committee as follows: for President, A. Starker Leopold and Gustav A. Swanson; and for Vice-President, Kenneth D. Carlander and Thomas R. Evans.

Upon recommendation by the Committee on Constitutional Revision, and upon a favorable vote of the Council, a motion to adopt a single set of By-Laws as drawn up by the Committee was put to a vote by mail ballot. The vote was 1208 to 18 in favor of adopting the new By-Laws.

During the year two new sections of the Society were approved by the Council. These are the California Section, having as its first President, A. Starker Leopold, and the Northwest Section with Lowell Adams and John J. Craighead, President and Secretary, respectively.

Because of continued requests for out-of-stock issues of the JOURNAL OF WILDLIFE MANAGEMENT and the Farm Pond Symposium, the Council approved off-set printing 400 copies each of Volume 13 (Nos. 1 and 2) and of the Symposium.

An inventory by Cayuga Press in January 1954 revealed that the following issues of the JOURNAL were no longer available: Volume 1, Nos. 1 and 2; Volume 2, all issues; Volume 3, all issues; Volume 5, Nos. 3 and 4 (only 12 and 16 copies of Nos. 1 and 2 remain); and Volume 7, Nos. 1 and 3. If new members are to be afforded an opportunity to obtain complete sets of the JOURNAL, it is obvious that reprinting of additional issues is necessary.

In anticipation of requests for the Cycle Symposium published in the January 1954 issue of the JOURNAL, 1000 reprints were obtained for sale. Demand for reprints of the article "Biologists in the Field of Wildlife Conservation" was considerable. This reprint was useful in answering requests from high school guidance

personnel and others interested in wildlife as a vocation.

The printing of these items, together with the 45-page Membership List which was compiled by Petrides and published as an appendix to the October 1953 JOURNAL, added considerably to expenditures. These extra printing costs should be redeemed, however, over a period of years, through sale of back issues and reprints.

Through the combined efforts of Bob Hines, who did the art work, and Durward Allen and your Secretary, certificates were prepared for Honorary Members and the winners of the Society's new Conservation Education Awards. The Wildlife Management Institute financed the printing of the former, while the latter was printed at Society expense. It is hoped that these certificates will make the awards more meaningful.

## FINANCIAL REPORT

I respectfully submit the following audited financial report of The Wildlife Society Inc. for the fiscal year March 1, 1953 to February 28, 1954.

### ASSETS

| | | *Amounts* |
|---|---|---|
| *Cash* | | |
| Checking Account (Bank of Silver Spring, Md.) | $4,644.72 | |
| Saving Account (Bank of Silver Spring, Md.) | 4,040.00 | |
| Permanent Fund (Emigrant Industrial Savings Bank) | 8,630.23 | |
| | | $17,314.95 |
| *Securities* — Market Values | | |
| 22 shs. State Street Investment Corp. | $1,375.00 | |
| 30 shs. Loomis-Sayles Mutual Fund, Inc. | 1,128.60 | |
| U. S. Government Bonds (12-year bonds) | | |

| Par | Cost | Date of Purchase | Redemption Value 2/28/54 | |
|---|---|---|---|---|
| $500.00 | $370.00 | April 1947 | $479.00 | |
| 500.00 | 370.00 | April 1947 | 479.00 | |
| 500.00 | 370.00 | Sept. 1948 | 474.50 | |
| 500.00 | 370.00 | Sept. 1948 | 474.50 | |
| | | | | 4,410.60 |
| | | Total assets | | $21,725.55 |

### INCOME AND DISBURSEMENTS

| ITEMS | | AMOUNTS |
|---|---|---|
| Bank Balance — March 1, 1953 | | $23,262.90 |
| *Receipts* | | |
| Dues | $ 9,250.86 | |
| Subscriptions | 2,179.92 | |
| Back Issues — Journal | 979.25 | |
| Dividends and Interest | 539.12 | |
| Sales — Index | 28.00 | |
| Sales — Reprints | 19.50 | |

| | | |
|---|---|---|
| Sales — Beard Overrun (W.M.I.) | 436.80 | |
| Sales — Needham Overrun (U.C.) | 45.99 | |
| Gifts | 11.94 | |
| Payments on Life Memberships | 100.00 | |
| Refund, Safety Deposit Box | 1.20 | |
| | | 13,592.58 |
| | | $36,855.48 |
| *Disbursements* | | |
| Journal — Printing and Mailing (5 issues) | $11,707.78 | |
| Membership list in Oct. issue | 648.00 | |
| Beard & Needham overruns | 482.79 | |
| Insurance on stock (3 years) | 101.19 | |
| | | $12,939.76 |
| Mailing Back Issues | | 249.33 |
| Editor's Expense | | 77.00 |
| News — Printing and Express | 220.51 | |
| Folding and Mailing (4 issues) | 158.88 | 379.39 |
| Printing and General Supplies | | 3,028.04 |
| Postage, Wires, Express | | 1,024.04 |
| Executive Secretary | | |
| Clerical Assistance | 600.00 | |
| Honorarium | 600.00 | |
| Travel and Meeting Expense | 119.64 | 1,319.64 |
| Fidelity Bond (3 years); Audit (1953) | | 169.93 |
| Refunds, Bank Charges, Bad Checks | | 158.05 |
| Contributions | | 155.00 |
| Award Engraving | | 4.36 |
| Conference Expenses (1953) | | 35.99 |
| Total Disbursements | | $19,540.53 |
| Cash Deficit | | 5,947.95 |
| Cash Balance March 1, 1953 | $23,262.90 | |
| Less Deficit, Current Period | 5,947.95 | |
| Cash Balance Feb. 28, 1954 | $17,314.95 | |

The Executive Secretary is bonded in the amount of $20,000. The stock of JOURNALS held at Cayuga Press, Ithaca, New York, is insured in the amount of $6,000 for fire and $6,000 for sprinkler leakage with the Continental Insurance Company. The respective expiration dates for the bond and insurance policies are August 24 and May 5, 1956.

DANIEL L. LEEDY, *Executive Secretary*

## REPORT OF THE BUSINESS MEETING OF THE COUNCIL

The Council assembled at 7:00 P.M. on March 7, 1954 in the Palmer House, Chicago, Illinois. Members present were C. H. D. Clarke, President; W. C. Glazener, Vice-President; Daniel L. Leedy, Executive Secretary; and Roger M. Latham, Leonard E. Foote, Thomas R. Evans, Lee E. Yeager, F. M. Baumgartner and A. Starker Leopold, Regional Representatives of Regions 1, 2, 3, 4, 5 and 6 respectively. Region 7 was not represented.

Following a brief report of the Executive Secretary in which information on membership, finances and other Society activities was presented, Editor Ollie Hewitt reported on JOURNAL matters. He showed that cost per page of printing had increased progressively from $6.62 in 1943 to $18.99 in 1954. An unprecedented number of 216 manuscripts were received for publication during 1953 compared with 76 in 1952 and 22 to date in 1954.

Dr. Hewitt, who was reappointed Editor of the JOURNAL OF WILDLIFE MANAGEMENT, was asked to investigate the possibility of offset printing of the JOURNAL in order to reduce costs and to report his findings to the Council.

The Council authorized the Editor to accept for immediate publication, papers for which authors are able to pay the entire cost of printing including any extra pages necessary in the make-up of the JOURNAL issue and providing that a paper of similar subject matter which may be on hand for regular publication be published in the same issue.

It was recommended that the incoming Council determine the possibility of securing a grant from the National Wildlife Federation made payable to The Wildlife Society for publication of special bulletins on wildlife training etc.

Henry S. Mosby was reappointed Editor of THE WILDLIFE SOCIETY NEWS; C. R. Gutermuth was reappointed Trustee to serve until 1957; Daniel L. Leedy was retained as Executive Secretary. Carl D. Shoemaker and F. Fraser Darling were recommended by the Council for election to Honorary Membership.

A proposal for a joint (family) membership was tabled.

Continued affiliation of the Society with the Natural Resources Council of America and the International Union for the Protection of Nature was approved. Contributions of $50.00 to each of these organizations were also approved. A request for the Society to contribute $25.00 to AIBS to enlarge the agricultural representation on the Scientific Manpower Commission was not approved.

The Executive Secretary was authorized and instructed to sell reprints of the 1953 Society Membership List at $.50 each to Members and non-members alike; and to sell the reprints of the farm pond and cycle symposia at $1.00 each.

The Council recommended that the incoming President appoint a committee composed of Members representing the various Sections of the Society to study the relations of such Sections to the parent Society.

It was agreed that for the present, at least, the Society should not reprint additional back issues of the JOURNAL but if there was sufficient demand, out-

of-stock issues might be reprinted later.

The Council approved a budget of $13,750.00 for the period of March 1, 1954 to February 28, 1955, with items as follows:

| | |
|---|---|
| Journal of Wildlife Management.. | $10,000.00 |
| Wildlife Society News..... | 750.00 |
| Mailing back issues..... | 250.00 |
| Affiliations (I.U.P.N., Natural Resources Council)..... | 100.00 |
| Society Employment Desk..... | 50.00 |
| Honorarium for Executive Secretary..... | 700.00 |
| Clerical help for Executive Secretary..... | 700.00 |
| Travel expenses for Executive Secretary..... | 200.00 |
| Office supplies, postage, express, etc..... | 750.00 |
| Contingency fund..... | 250.00 |
| | $13,750.00 |

Resolutions were considered and two were approved for presentation by the Resolutions Committee at the annual business meeting.

To clarify the status of the By-Laws of the Society the following Council action was taken:

1. The Council, recognizing that there was an urgent need for incorporating The Wildlife Society on March 25, 1948, and finding no record of ratification of this act in any of the subsequent meetings, does hereby ratify and affirm the legal action taken by the incorporators in the District of Columbia on the above date.

2. The Council, having authorized the taking of the mail vote on January 26, 1954 for the adoption of a single set of By-Laws for the Society, hereby affirms the action of the Executive Secretary in closing the ballot on February 26, 1954 and declares that the tabulation of 1,208 votes for and 18 votes against the adoption of said By-Laws is accepted as the final result.

3. In order to record the final action of the membership in the acceptance and approval of the single set of By-Laws for the Wildlife Society, adopted by the mail vote of February 26, 1954, the Council hereby recommends that the adoption of said By-Laws be ratified by an affirmative vote of the membership in the annual meeting of the Society on March 8, 1954, and that the members repeal any and all existing rules, regulations and By-Laws that may be in conflict therewith.

Respectfully submitted,

DANIEL L. LEEDY,
*Executive Secretary*

## MINUTES OF THE ANNUAL MEETING, MARCH 8, 1954, PALMER HOUSE, CHICAGO, ILLINOIS

The eighteenth annual business meeting of the Wildlife Society was called to order by President C. H. D. Clarke at 8:10 P.M. March 8, 1954 at the Palmer House, Chicago, Illinois. Approximately 170 Members were present. Minutes of the previous meeting were approved as published in the JOURNAL OF WILDLIFE MANAGEMENT, 17(3), July, 1953.

Following brief remarks by the President in which the status of the Society's By-Laws was reviewed, a motion was made by Caleb Glazener and seconded by Lee Yeager that the Society rescind

any or all existing rules, regulations or by-laws by which it had been governed and affirm the mail vote, closed February 26, adopting a single set of By-Laws for The Wildlife Society, Incorporated. The motion was carried.

The Secretary's Report and the Treasurer's Report were read and approved.

The Report of the Council meeting held March 7 was adopted. A motion to rescind the action taken by the Council in authorizing the Editor to accept for publication in the JOURNAL, manuscripts for which all publication costs would be borne by the author or his agency—this in order to increase the size of the JOURNAL at no extra cost to the Society and without delaying publication of similar articles submitted to the Editor, was lost.

Louis Krumholz and Lansing Parker spoke in favor of increasing annual dues, pointing out that other scientific societies had found it feasible to do so, with rising printing costs, and that the increased dues would enable the Society to enlarge the JOURNAL to accommodate an unprecedented number of manuscripts being submitted for publication.

Starker Leopold and S. A. Graham favored maintaining the $5.00 membership dues as long as the Society could operate effectively within the current income. Walter Taylor and Durward Allen suggested that the Society might be able to secure an endowment for aid in publishing the JOURNAL. Durward Allen also suggested that consideration be given to the possibility of publishing long articles as a series of wildlife monographs. W. B. Davis encouraged Members to consider life memberships in the Society.

At Krumholz' suggestion the President took a poll of the Members present at the meeting to get an expression of feeling toward increasing the annual dues to $6.00. The group was fairly evenly divided on this question and President Clarke suggested that the incoming Council further consider the whole problem of dues, endowments and feasibility of reprinting out-of-stock issues of the JOURNAL.

F. Fraser Darling and Carl Shoemaker were elected by unanimous vote to Honorary Membership in the Society.

The Regional Representatives or their alternates summarized activities in the seven regions. These reports, together with information on membership given in the Secretary's Report, showed that the Society had continued to grow during the past year.

Reports of the following committees were read and approved: Employment; Job Standards; Professional Standards; Research Needs; Nomenclature; Awards —Fishery, Terrestrial and Conservation Education; and Resolutions.

It was resolved that Bob Hines, who did the art work for the newly created Honorary Membership and Conservation Education Award certificates, receive the Society's vote of thanks and expression of appreciation for his excellent work: and that the Wildlife Management Institute be commended with thanks for making possible the Society Meeting in conjunction with the North American Wildlife Conference.

Durward Allen, Society representative on the National Research Council, and Clarence Cottam, Representative on the Natural Resources Council of America, gave brief reports on the activities of these two organizations. The President indicated that although Victor

Cahalane, Society Representative on the I.U.P.N., was not present, he had written recommending continued support of the I.U.P.N. by the Society.

John Anderson reported on his attendance at the meeting of the Waterfowl Advisory Committee in Washington, D. C. He was well impressed by the meeting and recommended that the Society continue its representation at this annual meeting, preferably by a non-Fish and Wildlife Service biologist.

C. R. Gutermuth urged that serious consideration be given to shortening the annual Society business meetings, particularly the time devoted to reports of the various committees and Regional Representatives. A motion, made by Dr. Cottam and seconded by Ben Glading, that the incoming President appoint a committee to investigate means of shortening the meeting, was carried.

The meeting was adjourned at 11:45 P.M.

Respectfully submitted,

DANIEL L. LEEDY,
*Executive Secretary*

## REPORT OF THE AWARDS COMMITTEE, TERRESTRIAL PUBLICATIONS MARCH, 1954

The Committee, after considering all literature available to them, recommends that the Wildlife Society give the award for the best publication in the terrestrial wildlife field to the publication "The California Condor" by Carl B. Koford, published by the National Audubon Society. Honorable mention should be given to the following publications: Wildlife in Alaska by Leopold and Darling; Wisconsin Fox Populations by Richards and Hine; Those of the Forest by Grange; The Importance of Beaver in Waterfowl Management at the Seney National Wildlife Refuge by Beard; Beaver Management in Maine by Hodgdon and Hunt; Migration of the Northern Fur Seal by Kenyon and Wilke.

In recommending the award, we feel that Mr. Koford's publication, while it was not about a game species, has all the elements that make it a worthwhile recipient of the Society's recognition in that the subject is of national interest in the conservation field, and that it represents a much more than adequate amount of field work written up in a sound, presentable, workman-like manner.

Respectfully submitted,

W. J. HAMILTON, JR.
NEIL HOTCHKISS
HOWARD L. MENDALL
BRUCE S. WRIGHT
BEN GLADING, *Chairman*

# REPORT OF THE AWARDS COMMITTEE, FISHERIES PUBLICATIONS MARCH, 1954

With the aid of the Executive Secretary, we have obtained a more definite concept of the policy that has been evolving on qualifications for the Award. As we now understand it, the person to be recognized and honored need not be an American and need not be a member of the Society. The treatise may have been published in the calendar year preceding the stated one, particularly if it came out late in that year. It need not be confined to management and may be primarily ecological. It should, however, be a scientific, documented paper, monograph or book presenting, in part at least, personal research. We recommend that such policies receive some discussion at the meeting, and that a statement be drawn up to guide future committees on awards.

With these qualifications in mind, the Committee on Awards for Fishery Publications for 1953 (including papers published late in 1952) has come to the following unanimous recommendations (Howard A. Schuck was forced to resign from the Committee during the year because of his preoccupation with defense work).

The Committee proposes that Herbert Spencer Davis receive the Award for his outstanding treatise on "Culture and Diseases of Game Fishes" (University of California Press, 1953). This book culminates and summarizes a long series of scholarly studies by Dr. Davis on the parasites, diseases, and nutrition of fishes, and on various phases of fish management—researches in which pure and applied science have been blended to common advantage. The book also covers the work of others.

The pioneering general text, "Fishery Science: Its Methods and Applications" (John Wiley & Sons, 1953), by George A. Rounsefell and W. Harry Everhart, is warmly commended as a major contribution to fishery biology. The profession also owes special thanks to D. G. Frey and F. E. J. Fry for their translation and publication of Franz Ruttner's stimulating "Fundamentals of Limnology." Honorable mention is also given to the revised edition of "Freshwater Fishery Biology," by Karl F. Lagler, and for the continuation of Kenneth D. Carlander's "Handbook of Freshwater Fishery Biology" (Carlander alone voting against mention of his own work).

Among the noteworthy papers issued during the last year or two, we single out for commendatory mention: "Principles Affecting the Size of Pink and Chum Salmon Populations in British Columbia," by Ferris Neave (Jour. Fish. Res. Bd. Canada, 9, 1953: 450-491); "Conditions of Stocks of Halibut in the Pacific," by W. F. Thompson (Jour. Cons., 18, 1952: 139-166); "The Life History and Economic Importance of a Burrowing Mayfly, *Hexagenia limbata*, in Southern Michigan Lakes," by Burton P. Hunt (Inst. Fish. Res., Mich. Dept., Cons., Bull., 4: 1-151); "Studies on Fish Preservation at the Contra Costa Steam Plant of the Pacific Gas and Electric Company," by James E. Kerr (Calif. Dept. Fish & Game, Fish Bull. 92: 1-66); "Artificial Freshets and Other Factors Controlling the Ascent and Population of Atlantic Salmon in the Le Have River, Nova

Scotia," by F. R. Hayes (Fish. Res. Bd. Canada, Bull. 99: 1-47); "Evidence for the Concepts of Home Range and Territory in Stream Fishes," by Shelby D. Gerking (Ecology, 34, 1953: 347-365).

The Committee feels that special mention should be made of K. Radway Allen's "The Horokiwi Stream, a Study of a Trout Population" (New Zealand Marine Dept., Fish Bull. 10, 1951: 1-231)—the most thorough study we know of any trout stream. Since the publication date was 1951 and the book-size paper was received in America early in 1952, it was not considered for the award by the present Committee. Had it been realized that the award need not go to an American or to a member of the Society, we believe that this publication might well have been honored by a previous Committee.

Respectful'y submitted,

KENNETH D. CARLANDER
ERNEST A. LACHNER
A. L. PRITCHARD
CARL L. HUBBS, *Chairman*

## REPORT OF THE COMMITTEE ON CONSERVATION EDUCATION AWARD MARCH, 1954

Our two long established awards for fisheries publications and for publications in the terrestrial wildlife field have traditionally considered only technical publications resulting from original research. Several times the committees selecting recipients for these technical awards have been urged to consider popular publications, but have felt that they were not eligible. The present committee was established last year to consider outstanding accomplishments in the field of wildlife conservation education, to fill this need.

To supplement their own knowledge, the committee solicited nominations from a number of key individuals throughout Canada and the United States, and from all state and federal conservation agencies in the two countries.

The governing rules which follow were in part established by the Society when it determined to have such a committee, and in part by the committee itself:

(1) Any type of wildlife conservation education accomplishment in the U.S. or Canada, whether by an individual or an organization, will be considered if it is of such a tangible nature that it is practicable for the committee to study it. For example, publications (including books, pamphlets, magazines, newspaper columns, etc.), motion pictures, and tape or disc recordings can be sent to the committee for study and consideration while a live TV program which was not filmed, or talks which were not published in some form could not be considered satisfactorily. An organized educational program, well described and documented, would be eligible.

(2) Anything appearing during 1952 or 1953 will be eligible. This is to avoid handicapping something which appeared near the end of the year, and to give each item the benefit of study by two committees.

(3) Consideration will be given to soundness and accuracy, originality, appropriateness for the desired audience, effectiveness in reaching it, and any evidence of results or impact on the audience.

We received about 50 different nominations from outside the committee for 20 different conservation education accomplishments. In the final voting the clear majority was for Charles Schwartz

and Jack Stanford of the Missouri Conservation Commission, in recognition of their joint efforts in producing the outstanding motion picture, "Bobwhite Through the Year," and the outstanding booklet, "Whirring Wings." The movie and the booklet both cover the life history, ecology, and management of the bobwhite quail in Missouri in an admirable manner. In each case these two men worked together, and the committee felt that each should receive an award. The Missouri Conservation Commission owns and has in constant use 21 prints of the film, and estimates that since it appeared only a year and a half ago it has been viewed by half a million people in Missouri. Still more remarkable, however, is the fact that agencies outside of Missouri have purchased 51 prints of this film at $370 per print for their use, even though it is clearly a Missouri product.

The booklet by Stanford with illustrations by Schwartz was printed in an edition of 80,000, which is nearly exhausted. The Missouri Conservation Commission feels that these two efforts to educate their constituents about the state's chief game bird have been eminently successful. They report that a recent public opinion poll in the state included questions on the best measures for increasing quail populations, and that the replies now were almost invariably biologically sound, in line with the teachings of the film and publication, including such suggestions as "improve the habitat," "restore cover," while only a few years ago the stock replies from the general public were always "to stagger the season," "kill the cats," "put a bounty on foxes," or "stock more quail."

The others high in the voting, were:

(a) Durward Allen for several outstanding publications during the last two years, including particularly his Merit Badge booklet for the Boy Scouts on Wildlife Management, and his little book in the Stackpole Company Sportsmen Series, entitled, "Pheasants Afield." His recent book, "Our Wildlife Legacy," had its official publication date as January 24, and hence was not considered by this year's committee.

(b) Frank Bellrose, for an outstanding booklet entitled, "Housing for Wood Ducks."

(c) R. W. Eschmeyer's series of children's books, of which several have appeared during the last two years.

(d) Michael Hudoba's monthly column on Washington conservation activities in "Sports Afield."

(e) Ted Petitt's outstanding Boy Scout program on conservation, which included a host of separate publications and individual efforts.

(f) The "New York State Conservationist" magazine was the only one of the state conservation department magazines given serious consideration.

Others clearly worthy of wide acclaim will merely be listed: Kentucky's Junior Conservation Club program, which in ten years has enrolled 24,000 youngsters; the Canadian Broadcasting Corporation's hour-long radio program, "Voices of the Marsh," made at Delta Waterfowl Research Station; a series of angling maps, issued by the California Department of Fish and Game, contains on the back of each map sound management material in a form particularly readily accessible to sportsmen; Ohio's film, "Let's Work Together," on farmer-sportsmen relations; the Wildlife Man-

agement short course offered by the University of Wisconsin for state game wardens; A. G. Lawrence, Winnipeg newspaper columnist, and W. T. Ward, British Columbia, game warden, have both done outstanding work in their localities; the weekly radio program on "Alaska's Wildlife" produced by the University of Alaska.

Several nominations were received, also, for the Disney nature films, and for Ed Dodds' cartoon strip, "Mark Trail," but the committee felt that commercial ventures of this kind were not comparable with the others which are largely non-commercial in nature.

The committee found it particularly difficult to compare the different types of educational efforts, such as publications with motion pictures, with comprehensive educational programs like that of the Boy Scouts. Some members of the committee felt quite strongly that it should be authorized to make as many as three awards, one for publications, one for visual aids, and one for general educational programs. This would certainly facilitate the work of the committee, but it is possible that a multiplicity of awards would lose in distinctiveness what it gained in convenience. The committee was unanimous, however, in feeling that a committee of this kind should be continued.

Respectfully submitted,

JACK CULBREATH
HARLOW B. MILLS
MICHAEL HUDOBA
KENNETH M. MAYALL
GUSTAV A. SWANSON, *Chairman*

# WILDLIFE STUDENTS, GRADUATES AND EMPLOYMENT TRENDS

## REPORT OF THE EMPLOYMENT COMMITTEE

## MARCH, 1954

For the fifth consecutive year the Employment Committee has gathered statistics on students majoring in fish and wildlife curricula in colleges and universities throughout the United States, Canada and Alaska; listed the number of students graduating; and indicated their success in obtaining employment in the wildlife field. For the third successive year the Committee has solicited information from state, provincial and federal conservation agencies concerning the number of fish and game personnel employed and/or the number of job openings in an effort to gain a clearer picture of the supply and demand of professional wildlife manpower. Results of the previous surveys have been published in the JOURNAL OF WILDLIFE MANAGEMENT, 14: 237-242, 15: 317-322, 16: 358-365 and 17: 355-360.

This year the Committee sent questionnaires to 67 colleges and universities, to the fish and game departments of all the states and Canadian provinces, to the Alaska Game Commission, to the Canadian Wildlife Service and to the U. S. Fish and Wildlife Service, Forest Service, National Park Service and Soil Conservation Service. The excellent re-

sponse from these training institutions and conservation agencies in providing information is gratefully acknowledged.

Throughout the year and during the 19th North American Wildlife Conference the Committee maintained an employment or job referral service. The dual objectives of this service were to aid Society members in locating fish and wildlife jobs and to assist conservation administrators in contacting qualified applicants.

### NUMBER OF STUDENTS

With no clear-cut definition of what constitutes professional wildlife conservation training, an effort was made to contact all the colleges and universities which had provided information regarding fish and wildlife students in past years or which we had reason to believe were giving training to students interested in the conservation field as a career. Fifty-seven of 67 schools to which questionnaires were sent responded (Table 1). Some of these, and probably others that we did not contact, offer basic courses in botany and zoology and turn out students well trained in mammalogy, ornithology, and icthyology. A few of the graduates from these schools enter the wildlife management field but many occupy teaching positions.

Although most of 52 institutions returning completed questionnaires do not grant degrees in wildlife management, they have more-or-less specialized curricula in which students can major in fish or wildlife management. These schools had an undergraduate enrollment of 1216 fish and wildlife students and a graduate enrollment of 472. Of the latter, 296 were working towards the master's degree and 176 towards the Ph.D. Last year 47 schools reported 1358 undergraduates and 434 graduate students. When enrollments of 44 schools reporting both years are compared, we find that there was a decrease of 154 undergraduates and 11 master's students and an increase of 9 doctoral students from 1952-53 to 1953-54. Expressed in percentage of gain or loss, enrollments of undergraduates and master's students decreased 11.4 and 3.6 per cent respectively while doctoral students increased 7.2 per cent.

Since 1949, however, enrollment of fish and wildlife students has remained relatively high. This is illustrated by comparing enrollments reported by 27 colleges and universities each year since 1949. These institutions reported enrollments beginning in the 1949-50 school year and for each year thereafter as follows: Undergraduates 1222, 1063, 996, 1021 and 893; graduates 281, 363, 352, 304 and 320. The ratio of undergraduates to advanced fish and wildlife students in these 27 institutions has been 4.3:1, 2.9:1, 2.8:1, 3.3:1, and 2.8:1 during the same 5-year period, 1949-53.

### GRADUATES AND THEIR STATUS

Fifty-two schools reported 512 students graduating during the school year ending September 30, 1953. This represented a decrease from the previous year when 568 students matriculated from 48 schools. The 1953 graduates received degrees as follows: bachelor's—343, master's—137, and doctor's—32. The status of these graduates can best be shown in tabular form (Table 2) where similar information is presented on students graduating the previous year.

Of the 512 graduates, 216 (42.2%)

TABLE 1.—DISTRIBUTION OF 1953–54 ENROLLMENT BY CLASSES AND SCHOOLS

| SCHOOL | UNDERGRADUATES | | | | | GRADUATES | | |
|---|---|---|---|---|---|---|---|---|
| | Fresh. | Soph. | Jr. | Sr. | Total | M.S. | Ph.D. | Total |
| Alabama Polytech. Inst. | 4 | 6 | 6 | 7 | 23 | 8 | 0 | 8 |
| Alaska, Univ. of | 17 | 2 | 1 | 4 | 24 | 8 | 0 | 8 |
| Arizona, Univ. of | 6 | 2 | 0 | 3 | 11 | 4 | 0 | 4 |
| British Columbia, Univ. of | * | * | 4 | 4 | 8 | 5 | 8 | 13 |
| Calif. Univ. (Berkeley) | * | * | 12 | 10 | 22 | 7 | 9 | 16 |
| Calif. Univ. (Los Angeles) [1] | * | * | 2 | 4 | 6 | 3 | 7 | 10 |
| Calif. State Poly. Coll. [1 2] | 2 | 1 | 2 | 5 | 10 | .. | .. | .. |
| Colorado A. & M. College | * | 12 | 12 | 8 | 32 | 8 | 0 | 8 |
| Connecticut, Univ. of | * | * | 1 | 2 | 3 | 5 | 0 | 5 |
| Florida, Univ. of [3] | * | * | 4? | 2? | 6? | 2 | 4 | 6 |
| Florida State Univ. [1 2] | .. | .. | .. | .. | .. | .. | .. | .. |
| Georgia, Univ. of | 9? | 7 | 5 | 4 | 25 | 1 | 7 | 8 |
| Humboldt State College | 20 | 20 | 11 | 14 | 65 | .. | .. | .. |
| Idaho, Univ. of | * | * | 8 | 6 | 14 | 6 | 0 | 6 |
| Iowa State College | * | * | 6 | 6 | 12 | 9 | 5 | 14 |
| Louisiana State Univ. | ** | ** | ** | ** | ** | 4 | 0 | 4 |
| Maine, Univ. of | * | 13 | 6 | 12 | 31 | 8 | 0 | 8 |
| Massachusetts, Univ. of | 17 | 16 | 8 | 9 | 50 | 6 | 0 | 6 |
| Miami U. (Fla.) Marine Lab. | .. | .. | .. | .. | .. | 5 | 0 | 5 |
| Michigan State College | 41 | 11 | 18 | 29 | 99 | 7 | 10 | 17 |
| Michigan, Univ. of | 1 | 4 | 2 | 17 | 24 | 7 | 13 | 20 |
| Minnesota, Univ. of | 8 | 16 | 9 | 7 | 40 | 7 | 4 | 11 |
| Missouri, Univ. of | 6 | 11 | 11 | 10 | 38 | 13 | 6 | 19 |
| Montana State College | 8 | 6 | 4 | 4 | 22 | 11 | 0 | 11 |
| Montana State Univ. | 10 | 7 | 7 | 7 | 31 | 7 | 0 | 7 |
| Nevada, Univ. of | 4 | 2 | 1 | 3 | 10 | 1 | 0 | 1 |
| New Hampshire, Univ. of | * | 4 | 3 | 6 | 13 | .. | .. | .. |
| N. Y. St. Coll. of Agr. (Cornell) | 27 | 13 | 12 | 15 | 67 | 17 | 21 | 38 |
| N. Y. St. Univ. (Syracuse) | ** | ** | ** | ** | ** | 10 | 5 | 15 |
| N. Carolina State College | 10 | 8 | 6 | 7 | 31 | 1 | 2 | 3 |
| Ohio State Univ. [4] | 8? | 8? | 13 | 16 | 45 | 15 | 7 | 22 |
| Oklahoma A. & M. College | 18 | 15 | 10 | 9 | 52 | 6 | 4 | 10 |
| Oklahoma, Univ. of | * | * | .. | 1 | 1 | 0 | 12 | 12 |
| Ontario Agri. Coll. | * | * | 1 | 1 | 2 | .. | .. | .. |
| Oregon State Coll. | 35 | 43 | 19 | 30 | 127 | 15 | 0 | 15 |
| Penn. State Univ. | ** | ** | ** | ** | ** | 15 | 1 | 16 |
| Purdue Univ. | 3 | 3 | .. | .. | 6 | .. | .. | .. |
| Rhode Island, Univ. of [1] | .. | .. | .. | .. | .. | 6 | 0 | 6 |
| San Jose State Coll. | 10 | 6 | 8 | 7 | 31 | .. | .. | .. |
| Scripps Inst. Oceanography (Univ. of Calif.) [1] | ** | ** | ** | ** | ** | 0 | 7 | 7 |
| South Dakota State College | 13 | 9 | 6 | 8 | 36 | .. | .. | .. |
| Southern Illinois Univ. | ** | ** | ** | ** | ** | 13 | 0 | 13 |
| Texas A. & M. College | * | 11 | 5 | 10 | 26 | 1 | 1 | 2 |
| Texas, Univ. of [1] | .. | 2 | .. | .. | 2 | 1 | 1 | 2 |
| Toronto, Univ. of [1] | ** | ** | ** | ** | ** | 6 | 7 | 13 |
| Utah State Agri. College | 22 | 11 | 11 | 13 | 57 | 21 | 8 | 29 |
| Virginia Polytechnic Inst. | * | * | * | 1 | 1 | 5 | 4 | 9 |
| Washington State Coll. | 8 | 5 | 3 | 6 | 22 | 3 | 2 | 5 |
| Wash. Univ. (School of Fisheries) | 23 | 9 | 10 | 22 | 64 | 7 | 6 | 13 |
| West Virginia, Univ. of | * | 7 | 0 | 3 | 10 | .. | .. | .. |
| Wisconsin, Univ. of [5] | * | * | 2 | 4 | 6 | 15 | 15 | 30 |
| Wyoming, Univ. of | 3 | 4 | 3 | 1 | 11 | 2 | 0 | 2 |
| TOTALS (52 Institutions) | 333 | 294 | 252 | 337 | 1216 | 301 | 176 | 477 |
| Schools having no specialized wildlife curricula but having some students who may be considered wildlife majors: | | | | | | | | |
| Colorado, Univ. of [1] | | | | | | .. | .. | .. |
| Indiana Univ. (Zoology) [1] | | | | | | .. | 6 | 6 |
| New Mexico, Univ. of [1] | | | | | | .. | .. | .. |
| Stanford Univ. [1] (Especially graduate work in fisheries) | | | | | | .. | .. | .. |
| Tennessee, Univ. of [1] | | | | | | .. | .. | .. |
| Washington, Univ. of (Zoology) [1] | | | | | | .. | .. | .. |

No replies from:

Arizona State College
Arkansas, Univ. of [1]
Delaware, Univ. of [1]
Hofstra College (New York) [1]
Kansas, Univ. of [1]
Kentucky, Univ. of [1]
Mississippi State Coll.[1]
College of the Pacific (Stockton) [1]
Rutgers University
Tulane University [1]

* Not designated
** No undergraduate wildlife curriculum
[1] Not included in 1952-53 school year tabulations
[2] Biological science students place emphasis on fisheries or wildlife but number not specified for Florida State University
[3] Includes wildlife students in School of Forestry and Department of Biology
[4] Includes students at Stone Institute of Hydrobiology
[5] Includes students in Departments of Wildlife Management and Zoology

TABLE 2.—STATUS OF GRADUATES ACCORDING TO DEGREE RECEIVED

| Field of Activity | Bachelor | | Masters | | Ph.D. | | Totals | |
|---|---|---|---|---|---|---|---|---|
| | 1951–52 | 1952–53 | 1951–52 | 1952–53 | 1951–52 | 1952–53 | 1951–52 | 1952–53 |
| | No. % | No. % | No. % | No. % | No. % | No. % | No. % | No. % |
| Game Research | 8 .... | 6 .... | 25 .... | 13 .... | 6 .... | 3 .... | 39 15.2 | 22 4.3 |
| Game Management | 47 .... | 38 .... | 34 .... | 26 .... | .. .... | 1 .... | 81 31.6 | 65 12.7 |
| Fish Research | 19 .... | 18 .... | 23 .... | 25 .... | 4 .... | 5 .... | 46 18.0 | 48 9.4 |
| Fish Management | 33 .... | 21 .... | 14 .... | 10 .... | .. .... | .. .... | 47 18.4 | 31 6.1 |
| Both fish and game mgt. or research | 7 .... | 2 .... | 2 .... | 9 .... | .. .... | 2 .... | 9 3.5 | 13 2.5 |
| Law enforcement | 5 .... | 7 .... | .. .... | 1 .... | .. .... | .. .... | 5 2.0 | 8 1.6 |
| Public Relations | 6 .... | 4 .... | 1 .... | 2 .... | .. .... | 1 .... | 7 2.7 | 7 1.3 |
| Teaching Wildlife | 2 .... | .. .... | 7 .... | 5 .... | 13 .... | 17 .... | 22 8.6 | 22 4.3 |
| Total fish and wildlife | 127 34.0 | 96 28.0 | 106 64.3 | 91 66.4 | 23 79.3 | 29 90.6 | 256 45.1 | 216 42.2 |
| Back in school | 92 24.6 | 86 25.1 | 31 18.8 | 23 16.8 | .. .... | .. .... | 123 21.6 | 109 21.3 |
| Teaching in other fields | 3 .8 | 2 .6 | 5 3.0 | 3 2.2 | 4 13.8 | .. .... | 12 2.1 | 5 1.0 |
| Military service | 74 19.8 | 92 26.8 | 5 3.0 | 10 7.3 | .. .... | .. .... | 79 13.9 | 102 19.9 |
| Other related fields [1] | 8 2.1 | 11 3.2 | 7 4.3 | 3 2.2 | .. .... | 2 6.3 | 15 2.7 | 16 3.1 |
| Other employment | 16 4.3 | 20 5.8 | 6 3.6 | 7 5.1 | 2 6.9 | 1 3.1 | 24 4.2 | 28 5.5 |
| Unknown | 54 14.4 | 36 10.5 | 5 3.0 | .. .... | .. .... | .. .... | 59 10.4 | 36 7.0 |
| Total | 374 | 343 | 165 | 137 | 29 | 32 | 568 | 512 |

[1] Graduates obtaining employment in such fields as forestry and soil conservation are listed here. Included here also in 1953 were two graduates who went into fur farming, two who were employed in museums, one who served as a professional guide and one who was engaged in oceanographic research, thus increasing the number of all graduates who obtained employment in the fish and wildlife field to 44 percent.

obtained employment in the fish and wildlife field, comparing favorably with last year's 45.1 per cent who obtained such employment. Twenty-eight, 66 and 91 per cent respectively of the 1953 bachelor, master, and Ph.D. degree graduates obtained fish and wildlife positions. Wildlife teaching continued to be the chief occupation of the Ph.D. group as 17 of the 32 Ph.D.'s entered this field. The military services claimed 20 per cent of all graduates compared with 14 per cent the previous year. Of the 343 bachelor degree graduates, 27 per cent went into military service and another 25 per cent returned to school for advanced training, leaving, in effect, only 58 per cent available for wildlife work. Actually only 96 (28%) of the bachelor degree graduates obtained wildlife employment. There has been a steady decline in the percentage of bachelor degree graduates obtaining fish and wildlife employment, the figures being 54, 44, 35, 34 and 28 per cent respectively for the 1949, 1950, 1951, 1952 and 1953 graduates. How much of this decrease has been due to increased numbers entering military service or returning to school is not definitely known. It is obvious, however, that graduates with more advanced degrees have had much better success in obtaining fish and wildlife employment. Recent graduates who have put in their "hitch" with the military are beginning to return to civilian status and are looking for jobs. Many of these went directly into military service upon graduation and thus never had wildlife jobs.

Although more graduates went into game research and management positions than into fish work, the latter field is opening up with more jobs available

each year. A few of the graduates continue to go into law enforcement and public relation fields. Mention should be made of the fact that in spite of the difficult nature of fish and wildlife research, more than one-third of the research jobs were filled by bachelor degree men, most of them, very probably, without having had so much as a special problem course in research.

Research men, whatever their training or level of recruitment, find it difficult to obtain advancement unless they switch increasingly to administrative work. Educational institutions appear to offer better chances for advancement, greater prestige and more security than afforded research men in many of the governmental agencies. Only when research men in applied agencies can look forward to promotion on the basis of professional ability (rather than on number of employees supervised) comparable with routine academic achievement can the conservation agencies hope to get their share of top-caliber research men.

As might be expected, the state conservation departments employ more of the graduates than the other conservation agencies combined. Distribution of employment by type of conservation agency is shown below.

Distribution of employment, 1950–53 as reported by wildlife professors (figures in per cent)

| Type of Agency | 1950 | 1951 | 1952 | 1953 |
|---|---|---|---|---|
| State and Provincial | 73 | 70 | 71 | 68 |
| Federal | 19 | 20 | 13 | 17 |
| Educational (Teaching) | 2 | 8 | 10 | 10 |
| Private | 6 | 2 | 6 | 5 |

## EMPLOYMENT AND MANPOWER NEEDS AS REPORTED BY CONSERVATION AGENCIES

The fish and game administrators were asked to report the following information: number of fish technicians, game technicians, conservation officers, and conservation education — public relations personnel employed during the fiscal year 1952-53; number employed during fiscal year 1953-54 at the time the questionnaire was completed; and number they anticipated would be employed between then and July 1, 1954. These were listed as replacements, new permanent employees and as temporary and/or seasonal employees. For the fiscal year 1952-53 the number of non-residents employed were listed, where applicable. In addition, employers were asked to indicate probable future needs for various types of employees, i.e., whether needs would increase, decrease, or remain about the same.

Replies were received from all state conservation departments, six Canadian provincial departments, the Alaskan Game Commission, the Canadian Wildlife Service and the U. S. Fish and Wildlife, Forest, National Park, and Soil Conservation Services.

In tabulating the information, 425 seasonal employees of the U. S. National Park Service and 600 Deputy Game Wardens employed by the Pennsylvania Game Commission were omitted from the temporary job listings. Likewise, in determining the percentage of non-residents employed by state conservation departments, only permanent fish and game technician and conservation education positions were tallied.

Fish and game administrators re-

ported that they had already hired or planned to hire, during the fiscal year 1953-54, a total of 638 employees including 134 fish technicians, 87 game technicians, 379 conservation officers and 38 conservation education and public relations workers. In addition, they had employed or planned to hire 961 seasonal or temporary employees—338 in fish management, 111 in game management, 417 primarily in law enforcement and 95 in conservation education work.

During fiscal year 1952-53 the same conservation agencies employed 711 men consisting of 162 fish technicians, 111 game technicians, 395 conservation officers and 43 conservation education or public relations personnel. Seasonal or temporary employees numbered 862 and consisted of 294 in fish management, 147 in game management, 371 primarily in law enforcement and 50 in conservation education work. These reports indicate a decrease of 73 (10.3%) in the number of full-time and an increase of 99 (11.4%) in the number of seasonal employees.

Employment by state and provincial conservation agencies accounted for 84 and 90 per cent respectively of totals for fiscal years 1952-53 and 1953-54.

Considering only state conservation departments, it is of interest that nearly one-third of total fish technicians, game technicians and conservation educators or public relations personnel employed to fill permanent positions were non-residents. Practically all conservation officers employed, however, were residents.

In reply to the question concerning future needs for fish and game technicians, conservation officers and public relations personnel, a majority of employers could foresee little change. There was some indication, however, of a need for increased numbers of fish technicians.

In considering supply and demand of trained manpower, it is of interest to reiterate that in the fiscal year 1953-54, fish and game administrators hired, or expected to hire, 259 fish and game technicians and 38 conservation education specialists in addition to 379 conservation officers. During the school year ending in September 1953, there were, as indicated above, 512 graduates. Of these graduates 216 or 72 per cent of the 301 remaining after deductions are made for those returning to school or going into military service, obtained fish and wildlife jobs. Last year a similar situation prevailed. This indicates that most technicians currently employed by conservation agencies are college graduates and that employment opportunities for graduates are still fairly good. The employment outlook for trained men would be improved, however, if conservation officer positions were converted into more secure and higher salaried jobs as the fish and wildlife management field evolves.

The opportunities afforded by conservation agencies for further academic training of recently employed technicians should be explored. In our opinion a liberal employer attitude toward such practice by the employee "on his own time" is an inducement equivalent to a definitely higher entrance salary.

### JOB REFERRAL OR EMPLOYMENT SERVICE

Following the recommendations of last year's Committee, the job application files assembled at the 18th North

American Wildlife Conference were retained throughout the year. Notice of the continuation of the Employment Service was published in Wildlife Society News No. 46 and in the Wildlife Management Institute's Outdoor News Bulletin. In canvassing the conservation agencies for information relative to employment and job openings, fish and wildlife administrators were urged to make use of the Committee's Employment Service and to suggest means of improving it.

A new file of personal data sheets submitted by Society Members in search of jobs was set up and included 53 applications prior to the 19th North American Wildlife Conference. Employers who contacted the Committee for likely candidates during the year were referred to applicants in both files. Although we do not know how many men received jobs as a result of our reference service or how much credit we can take in the instances in which applicants are known to have received employment, both job seekers and employers are taking advantage of the service.

During the conference 66 more members filed applications at the job referral desk, making a total of 119 applications. The applicants included recent graduates, students who were about to graduate and biologists who had been employed for some time.

On the form used, the job applicant was asked to list his first, second and third choices as to type of position he desired. Allowing 3 points for first choice, 2 points for second choice, and 1 point for third choice and multiplying by the number of these respective choices specified by the applicants, we should get some conception of the availability or surplus of personnel according to field of specialization. On this basis we found that job categories and their weighted values were as follows:

| | |
|---|---|
| Small (upland) game research | 67 |
| Waterfowl research | 61 |
| Waterfowl, general or management | 50 |
| Big game management | 44 |
| Big game research | 42 |
| Small (upland) game management | 38 |
| Fisheries research | 38 |
| Big game, general | 35 |
| Information and education (public relations) | 34 |
| Fur research and/or management | 33 |
| Small (upland) game, general | 32 |
| Habitat and refuge research/or management | 27 |
| Fish management, general | 27 |
| Game management, general | 27 |
| Teaching | 24 |
| Mammal research | 18 |
| Predatory animal research and/or control | 14 |
| Wildlife administration | 10 |
| Law enforcement | 6 |
| Small mammals, general | 6 |
| Water conservation | 5 |
| Marsh research or management | 5 |
| Biometrics | 3 |
| Disease | 3 |
| Marine mammals | 2 |
| Farm pond research | 1 |
| Insecticides research | 1 |

Prior to the Chicago conference, administrators requested assistance in locating candidates for the following positions: fishery biologists (primarily research) 5; information and education specialists, 4; big game biologist, 1; refuge manager (private marsh), 1; pilot biologist, 1; upland game man (prairie chicken), 1; wetlands biologist, 1; game management biologist, 1; and college wildlife teacher, 1.

At the conference, employers were looking primarily for fishery biologists, although there were requests, also, for public relations men and for an aquatic

entomologist, a limnologist and a habitat development project leader.

Obviously, on the basis of this small sample, the employment outlook for job candidates having had experience or specialized training in fishery biology and public relations work is brighter than that of small game and big game biologists. It would appear that more attention might be devoted in the training institutions to such areas as public relations, law enforcement, wildlife administration, and marsh management in an effort to better synchronize the output of graduates to current manpower demands of conservation agencies.

The minimum acceptable salaries listed by job applicants fall into the following patterns on the basis of degrees held by candidates:

| | Ph.D. | M.S. | B.S. |
|---|---|---|---|
| $6000 and up | 2 | | |
| 5000 - 5999 | 3 | 5 | 2 |
| 4000 - 4999 | 2 | 9 | 4 |
| 3000 - 3999 | | 28 | 35 |
| 2000 - 2999 | | | 3 |
| 1000 - 1999 | | | 1 |

Respectfully submitted,

JOHN L. BUCKLEY
JUSTIN LEONARD
W. H. MARSHALL
PAUL TULENKO
DANIEL L. LEEDY, *Chairman*

## REPORT OF THE COMMITTEE ON RESEARCH NEEDS
## MARCH, 1954

It has been suggested that recommendations this year present some specific problems rather than be restricted to the broader generalizations of the previous two reports.

To concentrate attention on pressing problems, which in many cases are also the most difficult, it may be desirable to set up some type of regional committees on research questions rather than continue on a national basis. Some fields needing special attention are important everywhere, e.g., land use problems, census methods, etc., but many are regional in character involving questions peculiar to an area, e.g., rodent and range relationship in the west, the sea lamprey in the Great Lakes, etc. It seems reasonable that groups familiar with a particular problem and also the administrative and organizational angles involved would work more efficiently. This proposition would need study and discussion. It is suggested as a possible field of activity for further study by the present Research Needs Committee or a similar committee appointed for that purpose.

Following is a classified list of suggestions offered by individuals scattered over the continent. It is unlikely that there will be agreement on ideas expressed; it will serve as a means of better acquainting us with some wildlife research problems about which many of us are concerned. As can be seen, there is considerable variation in the degree of specificity. Actually many suggestions presented could still be characterized as broad rather than specific. An attempt has been made to classify them somewhat roughly into groups. Naturally there has been some consolidation but as little complete elimination as pos-

sible. There is a certain amount of inevitable overlap and duplication, which may suggest to some too much of a scatter-gun approach.

A. ORGANIZATION AND ADMINISTRATION

A considerable number of individuals feel that wildlife research stands to benefit most by increasing the emphasis on better organization and coordination of research programs. An important phase of this includes the permanent establishment and development of satisfactory relations with administrative organizations in conservation fields which have a significant influence on wildlife research activities. Examples follow.

1. Work with and through the International Association of Game, Fish and Conservation Commissioners and particularly with a committee of this organization such as the Federal Aid Committee.
2. Have specific and concrete proposals to lay before administrators rather than depend on generalizations and philosophical abstractions.
3. Development of some type of "Operations Research," as it applies to wildlife, i.e., select problems, consider the available staff and assign phases of the problem to those best fitted, and decide how much money and time should be invested in the various phases.
4. Organization in Wildlife Society or International Association of Game, Fish and Conservation Commissioners of a cooperating group with Society of American Foresters in their 25-year Forestry Research Project.
5. Development of the research team idea using a number of specialists in attacking the most difficult problems. Better utilization of allied sciences and their personnel.
6. Finding the best way to "sell" the idea that research, academic as well as applied, is an essential part of management.
7. Separation of inventory from research programs.
8. Reduction of semi-official channels of publication in the wildlife field. "Job completion reports," which are regarded as publications by some authors, are making the bibliographic work exceedingly difficult and causing endless confusion.

B. LAND USE PROBLEMS

1. Wilderness areas vs. grazing, cutting, flooding, etc.
2. Predator—rodent relationships.
3. Rodents and forage production.
4. Mammalian influences on watershed management.
5. Competition between livestock and game.
6. Influence of agricultural uses of herbicides and insecticides on wildlife.
7. The effect of Soil Conservation Service practices on agricultural lands in respect to influence on wildlife.
8. Wet lands and drainage problems in respect to wildlife.
9. Understanding of how wildlife management can harmonize with other land uses.
10. Farmer-sportsman relationships.

C. TECHNIQUES

1. Standardization of research procedures and terminology.
2. Better experimental design with greater utilization of adequate statistical techniques and better tabulation and analysis of data.
3. Develop and refine methods of estimating size and composition of wildlife populations and, in addition, develop means of predicting them two or three years in advance.
4. Development of proven techniques which can be employed in practical land-use programs.
5. Ways and means of increasing utilization of less-preferred species of fish and game.
6. Means of repelling many forms of desirable wildlife from areas in which they cannot be tolerated, e.g., ducks in rice or wheat fields, deer in orchards, etc.
7. Effects of herbicides when used on a practical basis in producing desirable habitat changes.
8. Evaluation of techniques used in marsh

and pond management such as:
a. Manipulation of water levels.
b. Special cultural practices.
1. Application of fertilizer.
2. Application of herbicides.
3. Burning.
4. Plowing.
5. Blasting.

9. Methods of increasing browse in browsed-out deeryards.
10. Techniques for managing western elk ranges.
11. Measurement of value for wildlife of various plant species.
12. Predator control in settled areas with special reference to foxes.
13. The use of fire in wildlife management and forestry.

D. BIOLOGY—
General
1. Development of principles of wide application which may cut across the species line. Use of species such as ground squirrels or meadow mice or others of high reproductive potentials may be best method.
2. Continuation of investigations into life histories of fish and game species. No "last words" have been said yet about any species.
3. Wildlife cycles or population variations as some may choose to call them. Need for organization of research stressed.
4. Measurement of annual production surpluses and working out methods of how to insure adequate utilization.
5. Organisms making up "food chains" for species of importance to sportsmen.
6. Whole question of habitat improvement for upland game.
7. Importance of disease or similar mortality factors to wildlife.
a. Botulism, fowl cholera, leucocytozoan infections and lead poisoning in waterfowl.
b. Rabies.
c. Raccoon diseases.
d. So-called "moose disease."
e. Unexplained deer losses in eastern U.S.
f. Beaver die-offs.

Special
1. Certain fishery biology and fishery resource problems of the large lakes and the sea, e.g., steelhead trout in the Great Lakes, tuna in the Pacific, etc.
2. Development of strains or varieties of wildlife food-plants able to live and produce seeds, fruits, buds, etc., under adverse environmental conditions, e.g., lespedezas in the north, etc.
3. Studies on animal or bird behavior under varying population pressures.
4. Importance of moisture loss through plant transpiration.
5. Qualitative nutritional influences on species distribution.
6. Effect of introductions on native fauna.
7. Water pollution and effects on wildlife.
8. Black bear as a game animal.
9. Particular emphasis on the population dynamics of pheasants in view of importance as a game bird, the money spent for propagation and the unexplained marked fluctuation in numbers in late forties.
10. Development of pheasant strains able to live and reproduce under what are presently considered adverse conditions.
11. Less important game species in northern states, e.g., doves, bobwhite, quail, and woodchucks; or such western forms as the mountain quail, band-tailed pigeon or the black brant.
12. Rarer species such as marten, fisher, lynx and otter.
13. Arrangement of forest openings for wildlife.
14. Importance as predators of such bird species as the golden eagle and vultures.
15. Better controlled field research such as by the use of islands.
16. Further research on the nutritive value of many wildlife foods.
17. Fur price situation in relation to furbearer populations and to regional economics.
18. Further investigations on fence-row ecology.
19. Increased emphasis on individual reactions of animals to their environment as a means of better understanding herd or flock responses.
20. Basic wildlife physiology, e.g., bacterial flora in digestive tract of deer, hematology, etc.

The following suggestions are not research needs from the strictly scientific point of view, but still may be very important to the success of any research set-up. In a sense they concern administrative aspects of research and as such, decidedly influence for good or for evil the operation of any research program. Indeed, it may be argued with considerable fervor and logic that they are more important in reality than the purely technical considerations in achieving some of our research goals:

1. Promotion of a better atmosphere for creative thinking and work by research personnel. Fewer "reports," less "projectitis," and less emphasis on rigid working hours. Much wildlife research is seasonal and does not begin at 8:00 A.M. and stop at 5:00 P.M. as some administrators seem to think. An article in "Harper's" for January 1954 by Leonard Engel should be read by researchers and administrators alike.

2. Higher standards of training of research workers. There is over-emphasis on technology and under-emphasis on teaching students to think and express themselves clearly.

3. Establish continuity in research progress. Set up plans in which the necessary amount of time—3, 10, or 20 years—is allowed. This is an extremely difficult problem where the set-up is dependent on year-to-year legislative appropriation.

4. Improvement by researchers in expressing their ideas clearly, both verbally and in written form. Both administrators and the public would have a higher regard for research if they understood what the researchers are talking about.

5. Emphasis on presenting clearly to the public the basic reasons why research (wildlife or any other) is carried on, i.e., first, we want to maintain a way of living or improve it; second, conditions are constantly changing which necessitates new knowledge if we are to continue to survive under desirable living conditions.

As has been pointed out, there is some repetition of points made by the Committee in its previous reports of 1952 and 1953. It would be difficult, if not impossible, to present entirely new and original concepts on wildlife research needs. The only different approach in this year's report was an effort to incorporate a cross-section of the thinking on the subject by the Society members. It must be said that there was a surprisingly good response. It was evident that there is considerable dissatisfaction among the Society members concerning the research picture. The Committee views this lack of complacency and this critical attitude as a healthy situation.

Respectfully submitted,

CLARENCE COTTAM
THOMAS R. EVANS
A. STARKER LEOPOLD
HARLOW B. MILLS
M. O. STEEN
S. C. WHITLOCK, *Chairman*

# THE WILDLIFE SOCIETY
# BY-LAWS

## ARTICLE I—Name

The name of this organization shall be The Wildlife Society, Incorporated.

## ARTICLE II—Objectives

The principal objectives of the Society shall be: (1) establishment of professional solidarity and maintenance of the highest possible professional standards; (2) development of all types of wildlife management along sound biological lines; and (3) publications to effect these ends.

## ARTICLE III—Membership

SECTION 1. The membership of this Society shall consist of the following classes: Members, Life Members, and Honorary Members.

SECTION 2. Membership shall be open to all persons interested in wildlife management.

SECTION 3. Any person may become a Member upon the endorsement of one Member and acceptance by the Secretary, or Executive Secretary.

SECTION 4. Honorary Members shall be persons who, upon a majority vote of the Council and a majority vote of the Members present at any stated annual meeting of the Society, are thus recognized for their distinguished service or outstanding achievement in the field of wildlife management.

SECTION 5. All classes of Members shall be entitled to vote, to hold office, to represent the Society officially when so appointed by the President or the Council, and to receive the JOURNAL and such other publications of the Society as the Council may direct.

SECTION 6. Unless otherwise provided, the majority of those voting will determine the results of any election or other balloting.

SECTION 7. Any Member may become a Life Member by paying the sum of $100, either in a lump sum or not less than $25 per year over a period not to exceed four years. Such money shall be deposited in the permanent fund savings account. Life Members shall be exempt from payment of annual dues.

SECTION 8 A Member shall be dropped from the list of Members after becoming one year in arrears of dues for the current year in which application is made. Any Member serving in the Armed Forces may obtain, at regular prices, back numbers of THE JOURNAL OF WILDLIFE MANAGEMENT for the time he was in arrears because of military service. All other delinquents shall pay current prices for back numbers.

## ARTICLE IV—Officers

SECTION 1. The officers of the Society shall be a President, a Vice-President, a Secretary, and a Treasurer, or an Executive Secretary as provided in Section 8 hereof.

SECTION 2. The officers shall be elected by mail ballot, except as provided below. The President and the Vice-President shall serve until the close of the annual meeting of the calendar year following their election and shall be eligible for re-election for two additional terms of one year each. The

Secretary shall be elected to take office in each odd numbered year and shall serve until the end of the annual meeting in the next odd numbered year. The Treasurer shall be elected to take office in each even numbered year and shall serve until the end of the annual meeting in the next even numbered year. Before June 1 of each year, the President shall appoint a Nominating Committee of five members, and before September 1 of that year, said Committee shall submit to the Secretary the names of two available Members as nominees for each office to be vacated. The Committee's nominations shall be published in the next October issue of THE JOURNAL OF WILDLIFE MANAGEMENT or THE WILDLIFE SOCIETY NEWS. Within 30 days of the date of mailing of this issue, the names of additional available nominees for any office to be vacated may be submitted by any voting Member in good standing, and any such nomination will be valid if supported by 5 per cent of the membership. The Secretary shall then mail to all members an election ballot bearing the Committee's nominations and those made by the membership as herein provided. Thirty days shall be allowed for the election ballots to be returned to the Secretary. The nominee receiving the largest vote for each office shall be declared elected. In case of a tie, the decision shall be made by a majority vote of the Council. The outgoing President shall appoint a three-member committee within thirty days after the election to audit the election ballots. The auditors' report on balloting shall be published in THE JOURNAL OF WILDLIFE MANAGEMENT or THE WILDLIFE SOCIETY NEWS.

SECTION 3. The President shall preside at all meetings of the Society, shall be Chairman of the Council, shall appoint all Committees, including those established by the Council, and perform all other duties incident to this office.

SECTION 4. In the absence of the President, or upon his inability to act, the duties shall be assumed by the Vice-President. In the event neither can serve, the Council shall appoint a President *pro tempore*.

SECTION 5. The Secretary shall be the Executive Officer of the Society under the general direction of the Council. He shall issue notices of annual or special meetings of the Society. A report covering his activities during the year shall be made by him to the Society at its annual meeting.

SECTION 6. The Treasurer, subject to such regulations as may be promulgated by the Council, shall be responsible for all funds of the Society, except the management of the permanent funds which are under the supervision of the Board of Trustees. The general fund checking and saving accounts shall be made subject to the signature of the Treasurer, who shall have the authority and discretion to make transfers between these two accounts, depending upon the working capital needed in the checking account for current operating expenses. The Treasurer shall be responsible for the safekeeping of the permanent funds and investment securities, which shall be held in custody for the Board of Trustees. The permanent fund saving account shall be made subject to the signature of the Treasurer, but no withdrawals shall be made from this account except by majority vote of the Board of Trustees. The Treasurer shall be bonded at the Society's expense

in the amount specified by the Council. An independent audit shall be made of his accounts at the close of each fiscal year, as directed by the President, prior to reporting at the annual meeting.

SECTION 7. Vacancies among the offices shall be filled from the membership by vote of the Council, for the unexpired term of the office, or until the next regular election.

SECTION 8. The Council may, by a majority vote, combine the offices of Secretary and Treasurer into one office entitled Executive Secretary, and select one Member to serve in this capacity. Likewise, the Council may, by a majority vote, eliminate the office of Executive Secretary, if conditions warrant, and restore the separate offices of Secretary and Treasurer, and have these offices filled in accordance with Section 2 hereof. However, a petition, having signatures of at least 10 per cent of the membership will be sufficient to require the Council to submit a ballot to the Members to determine their approval or disapproval of the appointment or discharge of an Executive Secretary. The Council may pay said Executive Secretary a salary and expenses at its discretion and within sound financial limits of the Society. The Executive Secretary shall perform the duties and make the reports required in Sections 5 and 6 hereof. The combining of the offices of Secretary and Treasurer may be made effective at the close of any annual meeting, provided that notice of such consolidation shall have been made to the membership at least six months prior to the change.

## ARTICLE V—Council

SECTION 1. The Society shall be governed by a Council, composed of the President, Vice - President, Secretary, Treasurer, outgoing President, and at least one representative from each of the Regions defined in Section 2 hereof, and which shall pursue such policies and principles as shall be in accordance with the provisions of these By-Laws, and the Statutes of the District of Columbia.

SECTION 2. Representatives to the Council shall be chosen, one from each region, as follows: The Regional Representative for each Region shall be nominated and elected annually by mail vote of the Members residing in each Region. Nomination ballots shall be mailed to all Members by the Secretary by August 1 of each year. Each Member may nominate three qualified persons residing in his region as his first, second, and third choice for representative from that Region. Thirty days will be permitted for Members to return their ballots. After the 30-day time interval, the Secretary shall tabulate the results. The Members' first choice will receive 3 points; second choice, 2 points; and third choice, 1 point. Names of the two nominees receiving the most points within each Region shall be listed on the annual election ballot. The name of any nominee for Regional Representative that may also have been nominated as an officer shall be placed on the ballot only for the officer position, and the name of the nominee for Regional Representative holding the next largest number of points shall be substituted for it on the ballot for Regional Representative. Within thirty days following the election, the President shall appoint a three-member committee to audit the ballots. Regional Representatives shall be eligible for re-election and shall take

office at the close of the annual meeting following their election. The Regions shall be as follows:

REGION 1: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia, and West Virginia.

REGION 2. Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Puerto Rico, and Virgin Islands.

REGION 3: Ohio, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Illinois, and Indiana.

REGION 4: North Dakota, South Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas.

REGION 5: Arizona, New Mexico, Texas, Oklahoma, and Mexico.

REGION 6: Washington, Oregon, California, Idaho, Nevada, Utah, Alaska, and Hawaii.

REGION 7: Canada.

Additional Regions may be established for similar representation by a majority vote of the Council.

SECTION 3. The Council shall, by a majority vote, have power to fill vacancies occurring in its numbers; shall recommend By-Laws to the Society for action not inconsistent with the Certificate of Incorporation and the Statutes of the District of Columbia; and shall perform such other duties as are prescribed herein. One-half of the Members of the Council shall constitute a quorum. In case a Council member is unable to attend a meeting, he is authorized to appoint a qualified member as an alternate on the Council, provided that he has so notified the President in writing. The appointment of any alternate to act for a Member of the Council shall be recorded in the minutes of the meeting.

SECTION 4. Upon consolidation of the offices of Secretary and Treasurer, and the selection of an Executive Secretary, said appointee shall be a member of the Council but shall not vote on Council affairs.

SECTION 5. The Editor and Associate Editors, including the Editor of THE WILDLIFE SOCIETY NEWS, shall be appointed by the Council. The Editors shall serve one year or until their successors are appointed, and shall be responsible for all matters relating to the publications of the Society, subject to such restrictions as may be imposed by the Council. The Editor of the JOURNAL shall be a member of the Council but said appointee shall not vote on Council affairs.

## ARTICLE VI—Board of Trustees

A Board of Trustees, consisting of three Members, shall be appointed by the Council to administer the permanent fund of the Society. One Trustee shall be appointed at each annual meeting for a term of three years. The Trustee with the longest service on the Board shall be the Chairman. In case of vacancies caused by resignation, death, or incapacitation, successors shall be appointed by the Council for the remainder of the term.

## ARTICLE VII—Publications

The Society shall publish a quarterly scientific journal (THE JOURNAL OF WILDLIFE MANAGEMENT) for distribution to the membership. This periodical may be sold by subscription or by purchase of single volumes or issues. Dis-

tribution of THE WILDLIFE SOCIETY NEWS shall be restricted to Members only.

## ARTICLE VIII—Meetings

SECTION 1. Unless the Council directs otherwise, the Society shall hold an annual meeting. The Council may direct that other meetings be held at places and dates selected by it. Due notice of such meetings shall be given to all Members at least thirty days in advance, either through THE WILDLIFE SOCIETY NEWS, THE JOURNAL OF WILDLIFE MANAGEMENT, or by letter or card to their last known mail address.

SECTION 2. Resolutions proposed for consideration at any meeting of the Society must first receive approval of the majority of the Council, and if approved subsequently by a majority of the Members attending the Society meeting, such resolutions shall represent the official view or recommendations of the Society.

SECTION 3. The order of business at the annual meeting, unless changed by a majority vote of the Members present, shall be as follows:

1. Approval of the minutes of the previous meeting.
2. Report of the Secretary.
3. Report of the Treasurer.
4. Report of the Regional Representatives.
5. Appointment of temporary committees.
6. Report and recommendations of the Council.
7. Action on business reported by the Council.
8. Reports of Committees.
9. New and unfinished business.

## ARTICLE IX—Sections

Sections of the Society may be authorized by the Council upon petition of ten or more Members. Sections may adopt necessary rules and regulations, provided that they do not conflict with the By-Laws of the Society. A report of its activities shall be presented by each Section at the annual meeting of the Society.

## ARTICLE X—Dues and Funds

SECTION 1. The Membership dues shall be $5 per year. Subscriptions for THE JOURNAL OF WILDLIFE MANAGEMENT shall be $5 per annum. No dues shall be charged Honorary Members.

SECTION 2. Annual dues shall be payable from January 1 in advance. Members in arrears shall forfeit their rights and privileges and shall receive no publications during the period of their delinquency.

SECTION 3. All monies or other assets received by the Society for special or undesignated purposes, exclusive of annual dues, shall be placed in the permanent fund. The Council shall review the financial status of the Society, from time to time, and determine by a majority vote what funds, if any, are to be transferred from the general fund checking or saving account into the permanent fund saving account under the control of the Board of Trustees. When any or all of the holdings in the permanent fund are required for Society business, and when so instructed by a majority vote of the Council, the Board of Trustees shall order the Treasurer or Executive Secretary to effect any necessary liquidation and/or transfer the stipulated amount to the general fund checking account.

SECTION 4. The Council may accept in the name of the Corporation, any bequests, grants, and trusts made for the purpose of advancing the aims and objectives of the Society, and when so accepted, the Board of Trustees shall have the power to receive and administer said securities, funds or other property, real and personal, which may be transferred to the Society by any person, firm or corporation; and may sell, transfer and assign, invest and reinvest the same or any part thereof, as well as any assets or holdings acquired through subsequent exchange or conversion, provided, however, that the exercise of such rights is not in contravention of the terms under which the property was accepted from the donor or devisor. Any and all such assets shall be held in custody in the permanent fund by the Treasurer, subject to the control of the Board of Trustees.

SECTION 5. The permanent fund of the Society shall be controlled by the Board of Trustees with full power to authorize the Treasurer or Executive Secretary by a majority vote, to purchase securities, sell, transfer and assign any of the stocks, bonds, or other registered securities standing in the name of the Society; and to execute, under seal, such form of transfer or assignment as may be necessary to constitute a regular transfer of said securities; and to execute and deliver in behalf of the corporation, proxies on any and all stock owned by the Society, appointing such person or persons as deemed advisable to represent said stock.

### ARTICLE XI—Fiscal Year

The fiscal year of the Society shall end the last day of February.

### ARTICLE XII—Amendments

These By-Laws may be amended by a majority vote of the Society Members who return ballots in response to a notice of the proposed amendment. Such notice must be mailed to all Members at least thirty days prior to the close of the ballot. Amendments may be referred to the Society for action either by a majority vote of the Members present at any annual meeting, or by a majority vote of the Council.

## OBITUARIES

### CHARLES CLEMONS DEAM

1865—1953

Charles C. Deam was born on a farm near Bluffton, Indiana, on August 30, 1865. In ill health since a stroke of paralysis on July 18, 1950, he died on May 29, 1953. His wife, Estella Deam, preceded him in death by a few weeks.

Mr. Deam was a graduate of DePauw University. In 1920, he was presented with an honorary M.S. degree from Wabash College; DePauw University bestowed an honorary Sc.D. in 1932; and Indiana University, an honorary LL.D. in 1939. The American Scenic and Historical Preservation Society presented him with the Pugsley Silver Medal in 1940, while in 1947, he received the Mary Soaper Pope Medal. Oddly enough, he did not study botany while in college and entered the drug business in Bluffton, being affiliated with the Deam & Harris Drug Store throughout life. It was not until he was 30 years of age, when his doctor

advised him to spend more time in the open, that Dr. Deam became interested in this subject.

This avocation soon replaced other interests, and he devoted full time to studies and botanical collections in all parts of the state. He visited every one of the 1,016 townships in Indiana on these trips and, when passing certain habitats years later, could relate the exact location of many different specimens. In addition to his interest in the Hoosier State, he also made trips to Mexico and Guatemala. His remarkable memory, insatiable curiosity, and collecting ability finally led to the collection of 78,000 specimens. Most of his herbarium, 63,000 specimens, is now the property of Indiana University.

Dr. Deam was appointed Secretary of the State Board of Forestry in 1909, and served in that capacity until 1913. He was Acting State Forester in 1917–1918, and State Forester from 1919–1928. From that date until 1940, he continued as State Research Forester.

His intensive studies led to the publication of "Trees of Indiana," "Grasses of Indiana," "Shrubs of Indiana," "Flora of Indiana," and many other scientific publications.

An arboretum started on his property at Bluffton in 1922, now contains more than 500 species of trees, shrubs and woody vines. A complete reference card was maintained on each specimen in the arboretum showing its history, growth and other pertinent data, including some notes on use by wildlife. Forty plants have been named for him, including the Deam oak, a cross between the chinquapin oak and white oak.

Dr. Deam served as past president of the Indiana Academy of Science, and held memberships in the Indiana Horticultural Society, American Association for the Advancement of Science, American and British Ecological Societies, Society of American Foresters, American Genetic Society, Torrey Botanical Club, and The Wildlife Society. The loss of this great scientist is deeply felt, particularly among his associates in the field of botany.—WM. B. BARNES

## RAY S. MESCHKAT

1928—1953

Killed in the same tragic plane crash that took his project leader, Donald Johnson, was Ray Sterling Meschkat.

Born at Houston, Texas, March 15, 1928, Ray graduated from San Jacinto High School in 1946 and then served two years as aviation machinist with the Navy. On his return he enrolled in Texas A. & M. College and received his degree in wildlife management in January, 1953.

He was married to Margret Marie Jaquez of Blanco, New Mexico, April 5, 1949.

Ray would have gone far in the field of wildlife management, for he was deeply in love with the outdoors, and was eagerly looking forward to the many lessons that he would soon learn in his chosen field.

A letter written by Ray to the Nevada State Fish and Game Commission before he joined their field staff reveals some of the sterling characteristics that make for top personnel. It reads as follows: "Are you looking for a young college graduate to employ in your division of the game commission—one who is eager to learn, willing to work hard, and willing to start at the bottom?"

It wasn't long before Ray proved he meant every word he had written and was scheduled to take over an antelope study, when he and Don flew to the Sheldon for meetings with refuge personnel.—NILS N. NILSSON

# REVIEWS

*Pheasants Afield.* By Durward L. Allen. The Stackpole Company, Harrisburg, Pennsylvania, 128 pp. illus. 1953. $1.00.

In producing this booklet, the author used a mill powered by a large hand crank, fitted with many sieves and augmented by efficient blowers to screen out a handful of viable seeds from a boxcar full of grain. The grain came from many lands; most of it was produced in the past two decades. Few men could turn the crank as well as Durward L. Allen. I could find no chaff in the seeds, and a careful search through the screenings showed practically no seeds worth planting. In case you are not acquainted with this kind of a mill, let's look at the seeds in another way.

The facts that Allen screened out of this boxcar of pheasant studies have been presented exceptionally well. Anyone interested in pheasants will be interested in this account of habits and management of pheasants in North America. Its easy-to-read style will appeal to all—whether they be young or old, sportsmen, administrators, farmers or technicians. *Pheasants Afield* is accurately written and reflects mature judgment in evaluation of the many studies referred to.

Each of the thirteen chapters tells an important story. I like the discussion and conclusions on stocking best. On p. 109 it is pointed out that, ". . . if you had the money, you could grow and shoot pheasants nearly anywhere, whether the land could produce them or not." This is not profitable business as the reader finds out on p. 83: "On California's stocked and heavily hunted 'cooperative hunting areas,' they consider the average cost of a cock pheasant in the bag to be around $10. Very likely that is better than the average for a harvested pheasant in most states. In Oregon the figure was $18." Allen concludes the chapter on stocking by pointing out that, "The new awakening of sportsmen to game-stocking realities has been reflected in changing state policies. Some of the nation's top administrators, trained and wide-awake men, inherited large propagation plants and a public conditioned to such methods. Several have been following a deliberate policy of telling the 'whole truth' on artificial methods at every opportunity. Who can fail to respect a man who says in effect, 'It's your money, and at present I'm wasting a part of it because the public insists on hanging on to an unproductive hatchery program. I don't like it and I'll use the money for better purposes just as fast as you become informed and permit me to.' " It is fitting that Michigan, where Allen began his pheasant studies, was the first state to terminate its policy of egg distribution and general stocking of pheasants.

In Chapter XI the author points out that preserve shooting aroused violent public opposition to what were considered to be "un-American" special privileges. However, with the proper kind of logic, public benefits can be sorted out of the preserve shooting program. On p. 111 the author states, "It is true that in heavily populated sections of the country, the area of open land has declined as the hunting army grew. Vandalism has, year by year, closed an increasing acreage of land to free hunting." In such sections "Private preserves furnish a kind of shooting that is beyond the means of the bulk of the hunting public, but they make it possible for the hard-pressed business or professional man who has but a few hours to spend to at least enjoy the feel of a gun and a shot at a living target." On the same page Allen points out that, "Few landowners have made anything from the publicly owned game which inhabited their property, and they quickly recognize when it gets to a negative value. They are understandably cold to any suggestion of habitat improvement or other measures to increase a resource which only adds to their troubles."

Only two minor items were found that I didn't like. On p. 21, where the spread of a population is discussed, the following statement is made: ". . . there is a tendency always to expand, but a balance is established because limitations in the environment are always there." The word "balance" is a handy word which wildlifers have used so long that it is used almost automatically. Actually, there probably never is such a thing as a balance in the wild. On p. 68 this statement is made: "It was calculated that of a representative 100 hens, 79 (round numbers) would produce

broods aggregating 698 chicks." The next sentence states that, "Field records indicated that these broods would average 8.7 young at hatching time . . ." Why not use a rounded number of "about 9 young?" Such fractions, which are used too frequently in reporting field studies, imply laboratory refinement.

Generally, the book is written so well that these minor criticisms would never be noticed. —IRVEN O. BUSS.

*Fishery Science / Its Methods and Applications.* By George A. Rounsefell and W. Harry Everhart. John Wiley and Sons, New York, 1953. xii+444 pp. illus. $7.50.

This book on fishery science and management consists of 11 major sections which include such subjects as "Natural Populations," "Improvement of Habitat," "Age and Growth," "Collecting Basic Data," "Managing Natural Populations," "Tagging of Fish," "Fish Ponds," and so forth. In turn, each section is subdivided into chapters which treat particular items more fully. For instance, under the section on "Natural Populations" there are chapters that explain "Factors Limiting Abundance," "Criteria for Separating Populations," "Effects of Exploitation," "Factors Affecting Estimation of Population Size," and "Methods of Estimating Population Size." In addition, there is a fairly comprehensive glossary of terms pertinent to fishery science.

At first glance, it appears that this book has covered virtually all the known aspects of fishery biology and management, and that there is at hand a ready answer to the needs of the administrator, research worker, and student. However, such is not the case. The tremendous scope of the combined fields of marine and freshwater fishery science is one of the most serious limiting factors of the book. Because that scope is so all-inclusive, there was apparently insufficient space available to adequately discuss all aspects of fishery science in the required detail.

To be sure, many characteristics of the biology of fish populations may be readily and properly applied to both types of habitat. Many methods used to estimate size of discrete populations, and size and composition of mixed populations, age and growth, mortality, etc., can be applied to marine and freshwater fishes with equal facility. On the other hand, there are many subtle differences between the biologies of individual fish populations of small ponds, of lakes, of the Great Lakes, and of the oceans; there are differences in rates of growth, maximum age, mortality rates, etc., of fishes that live in different waters, especially in different latitudes. By and large, the field of marine fishery science is more thoroughly covered than is that of fresh waters.

In the section on fish ponds, the information applies primarily to ponds in southeastern and northeastern United States. Although much research has been performed in the central, southwestern, and western parts of the country, very little of that information has been included. The small pond is probably more susceptible to vagaries of biology than any other kind of impoundment. Characteristics of the surrounding terrain, type of soil on which the pond is located, value of the water for livestock, irrigation, spraying of orchards, etc., frequently apply serious limitations to fishery management procedures that can be used. Although bass-bluegill combination has been widely recommended, it still has not been widely accepted among research workers. There is, at present, great need for additional research in all sections of the continent on management of small ponds for fishing.

The authors have used many terms synonymously for which the correct meanings are quite different. For instance, the terms "yield," "production," and "productivity," are used synonymously, even to the point of using one term to define another in the glossary. Such errors in definition are unfortunate, especially in a book that is recommended as a textbook for students. It is even more unfortunate that the authors quoted, and then ignored, the writings of other workers who made a particular effort to clarify the meanings of such words.

In general, the coverage of the various fields seems to represent, primarily, personal experiences of the authors. Although many references are cited, relatively little cited material is incorporated in the text.

It is not my intent to dwell on all of the errors nor to praise all of the truths included in this book on fishery science. The authors are perhaps well aware of many errors and omissions that have been committed. Suffice it to say that there is little doubt that "*Fishery Science: Its Methods and Applications*" is the

most comprehensive of the limited number of textbooks in this field. It indicates that the problems that continually confront the fishery biologist cannot be accurately appraised unless the biologist in question has had adequate, high-quality training in such basic sciences as zoology, botany, chemistry, physics, etc. On these bases it is to be recommended.—LOUIS A. KRUMHOLZ.

*Wildlife Management / Fur Bearers, Waterfowl and Fish.* Vol. II. By Reuben Edward Trippensee. McGraw-Hill, New York. 1953. xii+572 pp. $7.50.

In this final volume (of two) on wildlife management, Dr. Trippensee attempts to describe water conservation, marsh management, and life histories, ecology, and management techniques for fur bearers, waterfowl, and fish. This reviewer finds it difficult to characterize the results coherently.

Certain portions of the book were written by prominent specialists in phases of wildlife or fisheries management for which they are best known. These chapters are lucid and concise, and contain clearly qualified statements. The remainder and bulk of the volume lacks these marks of careful workmanship and precision.

A distressing lack of organization is evident. Not only is there overlapping of context with the several contributing authors (something to be expected in any such attempt) but organization is lacking within the general text itself. It seems incongruous to place the Alaska fur seal, badger, and opposum in one chapter. In the chapter on cats the range of the puma is given twice and in somewhat dissimilar fashion. On adjacent pages in the discussion of the Canada goose the same data on distance of nests from water is repeated. In the wood duck section, nesting in trees or nest-boxes is indicated five different times.

It appears to this reviewer that basic concepts of management are frequently obscured or omitted. Thus, although the registered trapline system of harvesting fur bearers in several Canadian provinces is described, one finds in the chapters on fur bearers only repetition of the application of seasons in relation to primeness of pelt and accessibility as management measures. In the discussion of fire for marsh management the relationship of this technique to plant succession is not indicated. Similarly, although the failure of eelgrass is mentioned in the section on the American brant, the overall significance of this catastrophe is not discussed.

Generalization in a rather meaningless way and without qualification is common. As an example of the former I cite "The sea otter is a well coordinated machine as to body covering, muscles, nerves, and intelligence." The lack of qualification of generalizations is exemplified by the statement that "grazing of cattle and horses is destructive where waterfowl nest," which certainly deserves qualification in the light of Bennett's monograph on the blue-wing teal and later studies. Further, many waterfowl biologists will question the statement that "no duck area is free from heavy hunting pressure."

The usefulness of this volume as a review of the literature is impaired by lack of scholarly attention to detail and interpretation. There is a most unfortunate scrambling of references in at least chapters 14, 15 and 24. Several important sea otter citations are completely missing although listed in the text. Even more unfortunate are cases of misinterpretation of authorities used. The muskrat aging technique is garbled. The adult male blue-wing teal is said to head south as soon as flight feathers are grown although the reference presumably quoted only states that they leave the Delta marshes at this time and bag check data cited in this volume show adult males are in the area during hunting seasons (September or later). In discussing the causes for the homing instinct in salmon the author takes an unsubstantiated guess of a 20-year-old-paper and presents it as the most probable explanation. This reviewer cannot reconcile the table on dimensions of the two scaup with the reference cited. The growth rate tables for small mouth bass are interpreted to show a rate in Tennessee three times that in Ontario when the average increment is only one-and-a-half times as great and only once is double. This "triple" growth rate is then said to be proportional to the growing season.

Two facets of the book deserve high commendation. The black line sketches of waterfowl by Peter Ward are truly delightful and the ingenious diagrams showing growth rates of the various fishes get their point across ad-

mirably and with clear-cut simplicity.

In summing up this review one can say only that the task of assembling detail on such wide varieties of subject matter, basic concepts, and terminologies may be a well-nigh impossible task and one which has certainly not been mastered in this attempt. It is unfortunate that the present author has tried to cover fields so divergent from his own area of specialization.—WILLIAM H. MARSHALL.

# BRIEFER ARTICLES

## A DEVICE FOR SAFE HANDLING OF WILD MAMMALS IN THE LABORATORY

*Lawrence Kilham* and *James H. Belcher*

Department of Health, Education and Welfare, Public Health Service, National Institutes of Health, National Microbiological Institute, Laboratory of Infectious Diseases, Bethesda 14, Maryland

In the course of studies on gray squirrels (*Sciurus carolinensis*) in the laboratory, these animals have frequently escaped and recapture has been difficult. Handling gray squirrels has also been somewhat hazardous, as they bite readily through thick leather gloves. A device designed by the junior author which is essentially a square plywood tunnel (Fig. 1) has simplified capture. To remove a squirrel from its cage, open the cage door slightly and slip a piece of cardboard over the opening. Cages with small doors are preferable for squirrels. Next, the open end of the catcher is placed against the cardboard, which is now pulled away, so that the end of the catcher can be pushed into the cage. A sliding plywood shield allows the catcher to be inserted in cage openings of various sizes without leaving space around the edges through which squirrels can escape. A stiff wire may be needed to coax the squirrel into the catcher. When the squirrel has entered, a metal panel is dropped into a slot in the upper side of the catcher confining the animal. We usually put squirrels in mouse jars to anaesthetize them before examining. This is accomplished by placing the catcher upright over the open top of the jar, the metal slide is removed, and a sliding prod (Fig. 1) pushed down, forcing the squirrel to drop out. The prod is needed when squirrels cling tenaciously to the inside.

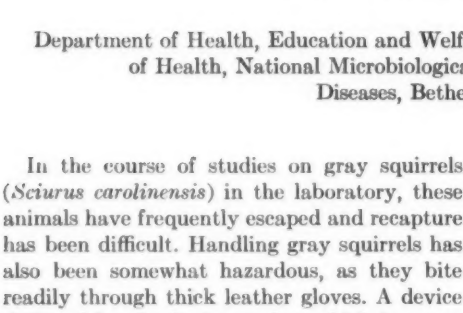


FIG. 1. Diagram of small mammal handling box.

This device is practical and simple to construct. Although designed for squirrels, it doubtless could be modified in size for other types of wild mammals.

Accepted for publication October, 1953.

# COMPARISON OF AN AERIAL AND GROUND CENSUS OF MOOSE[1]

*R. Y. Edwards*
B. C. Forest Service, Victoria, British Columbia

## INTRODUCTION

In March, 1952, the Parks and Recreation Division of the B. C. Forest Service conducted an aerial census of the moose in Wells Gray Park (Lat. 52°N, Long. 120°W). The method employed and the results obtained have been reported in detail (Edwards, An Aerial Moose Census, B. C. Forest Service Res. Note No. 23, 9 pp., illus., 1952.) and are summarized in this paper. During the same month of the aerial census a ground party of two men on snowshoes counted moose on the same moose range.

The writer believes that wildlife census methods can yield data containing large errors, and that before any method is accepted as reasonably accurate it should yield results similar to those obtained from an entirely different method. Accordingly these two censuses were conducted more or less concurrently.

While it would be useful to compare the costs of the two methods, this aspect has not been analysed. In both the aerial and ground operations considerable time and effort were expended in gathering data not strictly classifiable as census data. In addition, it appears premature to calculate costs when the relative sampling efficiency of each method is not yet fully known.

## CENSUS CONDITIONS

Topography and vegetation often affect the success of census methods. Flat terrain and an open vegetative cover provide ideal conditions for visual counts. The Wells Gray moose range has favourable conditions for such counts. This range is contained in the relatively flat bottomlands of a broad intermountain valley, while its vegetation consists mainly of open stands of willow and aspen with little coniferous admixture. In winter leafless vegetation and snow-covered ground contribute to good visibility both on the ground and from the air.

## AERIAL CENSUS METHOD

The aerial method used attempted to provide counts on narrow strips of known width and length. The pilot was instructed to fly uniformly at 200 feet from the ground, but under some flying conditions 300 feet was considered to be a more accurate average. Observers on both sides of the plane counted only moose within 30 degrees from the vertical, or at an elevation of 200 feet the total strip width was 232 feet. The 30 degree angle was established by each observer lining up a piece of cellulose tape fixed to the window with a cord tied and taped to the wing strut. When these were in line, animals below that line were within the census strip.

Lengths of strips were determined by flying between known points, or in a few cases by estimating ground speed and timing the counting period.

Three census flights were undertaken, each flight sampling the entire winter range with approximately a six per cent sample. Use of a DeHavilland "Beaver" airplane enabled a minimum counting speed of about 80 miles per hour with lowered flaps.

## AERIAL RESULTS

The aerial census sampled 60 square miles of range. Population figures calculated from the data of each flight were rather variable, due no doubt to sampling errors. The figures obtained were 2148, 2328, and 1764.

Since the ground count was restricted by snow conditions to the southern two-thirds of this range, aerial data from this part of the range must be used for comparison. Data from three aerial counts are summarized here.

| | March 11 | March 12 | March 13 |
|---|---|---|---|
| Square miles sampled | 1.8 | 2.6 | 2.6 |
| Moose seen | 85 | 123 | 92 |
| Moose per square mile | 47 | 47 | 36 |

As in the figures for the entire 60 square miles, data for the southern two-thirds of the range are quite variable. Further calculation would place the moose population on these 40 square miles at 1880, 1880, and 1440. If the figures from the three flights are combined to

[1] The field co-operation of P. W. Martin, B. C. Game Department, and of L. E. Cook, J. Norman, and C. Gagliardi, all of the B. C. Forest Service, made this study possible.

obtain a single population figure there is a suggested moose population of 1720 animals.

### GROUND CENSUS

During the month of the aerial census a ground crew counted moose on short sample strips scattered over the 40-square-mile area. The men employed were excellent woodsmen but were not familiar with sampling techniques except as they applied to strip cruising in forestry. They were therefore instructed to walk in straight lines between points separated by known distances, counting only those moose seen within 200 feet of their line of travel. The range offered good visibility through open stands of leafless bushes with the result that this simple type of "moose cruise" seemed to offer excellent possibilities for success.

Lack of accurate maps for the area necessitated that strips be chosen between points of known location as determined by previous land surveys. This resulted in most strips being located on the valley bottomlands where surveyed lots were more numerous. Since these may have contained slightly denser stands of moose than did the rest of the range, census figures may be too high by a small margin.

This ground crew censused 17 miles of strip 400 feet wide, or about 1.3 square miles. They saw on this area 73 moose, eight of which were concentrated about a haystack at the edge of a strip. These eight are omitted from the rest of the calculation on the grounds that they represent an abnormal concentration. These figures give, then, 50 moose per square mile or about 2000 moose in the 40 square miles sampled.

### AERIAL CENSUS ACCURACY

A previous paper (Edwards, *op. cit.*) has discussed the inaccuracies of the aerial method. Among these are the possibility of misjudging aircraft height and therefore width of sampling strip, effect of sloping ground upon strip width, and difficulty of seeing moose in an area dotted with charred logs and stumps when the ground is passing rapidly because of low flight. Related to this last, and probably the most serious factor affecting accuracy, is effect of eye fatigue. It was found that counting efficiency dropped through a census period of one hour. This efficiency drop was most marked when counting from the left side of the aircraft used. The left observer was placed behind the pilot and used a narrow window. The right observer was beside the pilot and was able to count both directly down and by looking well ahead along the strip. Looking down for long periods upon a narrow strip was fatiguing at both windows, but the narrow left window was more tiring. No matter which observer occupied this window, the left observer obtained consistently lower counts than did the other. Right window counts ranged from 33 to 100 per cent greater on the three flights. In all flights 387 moose were seen on the counting strips, 236 from the right window, and only 151 from the left.

Further study is needed to evaluate this variation and its cause, but it seems improbable that in 220 miles of counting that anything but observer efficiency could account for such a peculiar discrepancy. It would appear that roughly 85 moose were missed from the left window and that the total count should therefore be increased by about 22 per cent.

### COMPARISON OF AERIAL AND GROUND FIGURES

The ground census showed that about 2000 moose were inhabiting 40 square miles of winter range. The aerial figures when taken at face value suggest a population of about 1720 moose. These two figures are reasonably close for general purposes, but are sadly dissimilar in view of the care taken to approach absolute accuracy as closely as possible in both census operations.

It is difficult to detect inaccuracies in most census methods. Those described above may contain many. The most important inaccuracy detected is that caused by eye fatigue in aerial counting, and this has been at least partially evaluated. It has been shown that the aerial figures might be increased by 22 per cent for greater accuracy. This correction, when applied to the aerial figures from the 40-square-mile range, increases the population figure from 1720 to 2098. This figure is very close to the ground census figure of 2000.

From the close agreement of the population figures obtained by the two methods it is concluded that both methods probably yield reasonably accurate figures. It is hoped, however, that further work will verify this accuracy.

Accepted for publication April 14, 1953.

# PORTABLE LIVE TRAP FOR DUCKS, WITH IMPROVED GATHERING BOX

*J. D. McCall*

Division of Fish and Game, Indianapolis, Indiana

Waterfowl trapping conditions in Indiana make portable, collapsible traps highly desirable. A 10′ x 6′ x 3′ single-funnel trap has been developed which knocks down to fit on a car top.

At the Hovey Lake banding station, the fluctuating Ohio River usually causes a gradual rise from 6 inches to 3 or 4 feet during the trapping period. This gradual rise in water level, usually experienced throughout November, prompted the adoption in 1949, of sheet-metal bait pans and steel posts in traps. By connecting each corner of the portable trap to a steel post with a 4-foot length of No. 12 wire, the trap could be raised when necessary, to maintain from 4 to 8 inches of water over the bait pan.

With firm soils and stable water levels of the desired depth, it is considered advantageous to set the trap on bottom. Under these conditions, the bait pan prevents feeding ducks from undermining the trap throat.

A gathering box which could be lowered or raised with the trap was highly desirable, since use of a dip net has been discouraged. It was also hoped the box could be constructed so one man could get all the ducks into the box with a minimum of time, exertion, and excitement. This is accomplished by hinging a jointed gate in a horizontal position to the back of the trap (Fig. 1). A quarter-inch rope, 18 feet long, runs from the front over the top of the trap, down through small pulleys to each of the free corners of the gate (Fig.2).

When the trap is set, the back edge of the gate is 4 to 6 inches above water. The front section and the front half of the back section are weighted to prevent floating. When the bander approaches the front of the trap, the ducks swim to the rear. With a pull on the rope, the birds are enclosed and lifted clear of the water, which prevents drowning as they crowd to the corners. The rope is hooked over the front corner of trap leaving operator free to proceed with banding (Fig. 3). A 20″ x 30″ opening in the rear of the trap allows the birds to be removed.

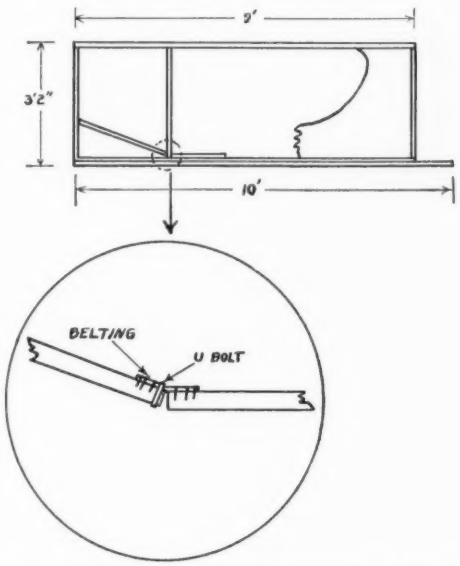


FIG. 1. Enlargement of recommended hinge for jointed gate.

As many as 40 blue-winged teal and a few pintails or mallards can be lifted easily at one time. When one trap contained 87 black ducks and mallards only half of the ducks were taken per lift.

FIG. 2. A quarter-inch rope is attached through two pulleys to the free corners of the hinged dip gate.

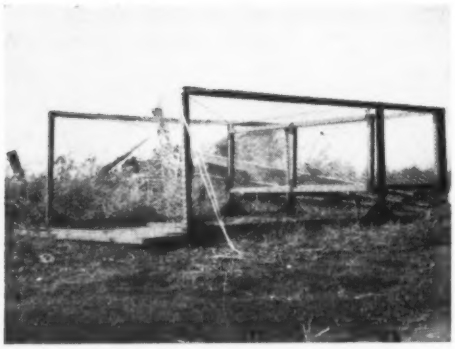

FIG. 3. When dip gate is lifted, rope is fastened over front of trap.

The funnel of the trap has been highly successful when constructed of 1½″-mesh, 16- or 17-gauge galvanized wire netting. The funnel mouth extends about one foot inside the trap, and may extend 6 to 8 inches above the water with good results for most dabbling ducks. Wood ducks often used this adjustment freely both as entrance and exit. Better results were obtained in retaining this species when the bait pan was raised within 2 inches of the surface and the opening woven together from the top down to within 3 inches of the surface of the water. In either case, the flexible ends of the wire netting along the vertical sides of the funnel mouth should be adjusted to within two inches of each other.

Approximately 4,500 ducks have been taken in this trap including black duck, mallard, blue-winged teal, wood duck, pintail, green-winged teal, ringneck, and scaup without mortality or serious injury.

When assembling the previously painted 2″ x 2″ wood frame, the sections should be connected and braced with 28-gauge galvanized sheet-metal and 1-inch box nails. This results in strong construction, and prevents sagging which would foul the dip gate. Triangular braces of 28-gauge galvanized sheet metal are used on the bottom edge of the panels and are submerged when in use. Small tabs, 1¼″ x 3″, of the same material, are used with good results on joints above water and do not restrict vision of feeding ducks. The light weight sheet-metal is easily cut with tin shears and offers little resistance to nailing (Fig. 4).

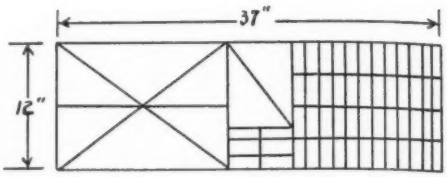


FIG. 4. Pattern for cutting braces and tabs from 38″ x 12″ sheet of 28-gauge galvanized sheet metal.

Corner braces should be used next to the wire only to avoid injuries to birds and bander, while tabs are used on opposite side of joint. Other important points in construction and assembly are as follows:

1. No. 12 wire is fastened to the bait pan with 1-inch cotter keys. This affords a means with which to lace funnel to pan.
2. Front corners are bolted to the bottom with 10″ x 12″ shelf braces, and 2¼″ x 3/16″ round-headed stove bolts.
3. Wire netting is stapled to inside of side and back frame, except wire netting should be crossed over to outside 2 feet before funnel upright on right side-panel. This makes the corner next to the funnel rounded.
4. A door 12″ high and 8″ wide is cut in left front corner to be left open when trap cannot be checked daily.
5. Inconspicuous and serviceable doors can be made from 1″ x 2″ welded wire, if cut 2 or 3 inches larger than openings in netting.
6. Sides are fastened to the bottom and the top laced to the sides with galvanized stove wire. When fastening frame sections together, one strand of stove wire at 2½-foot intervals is satisfactory if drawn tight with pliers.
7. Dip gate is 68 inches wide leaving one inch clearance on either side for free movement. Proper bracing throughout the trap is important in insuring smooth operation of dip gate.
8. A partial partition of 1″ x 2″ weld wire should be fastened to the sides and top of trap so as to give the dip gate something to close against. When braced along its lower edge by a ¼-inch iron rod it prevents the ducks from escaping back into

the trap by climbing over the top edge of the dip gate.

9. Less material and labor is required to construct a non-collapsible trap, in the event that it is to be used only at one location.

LIST OF MATERIALS NEEDED FOR FRAME

SIDES
- 4 — 108″ x 2″ x 2″ fir
- 6 — 34″ x 2″ x 2″ fir
- 2 — 6″ x 16″ 28-ga. galv. sheet metal braces
- 4 — 6″ x 8″ 28-ga. galv. sheet metal braces
- 18 — 1¼″ x 3″ 28-ga. galv. sheet metal tabs
- 4 — 2¼″ x 3/16″ stove bolts and 2 washers

BACK
- 2 — 66½″ x 2″ x 2″ fir
- 2 — 34″ x 2″ x 2″ fir
- 2 — 6″ x 8″ 28-ga. galv. sheet metal braces
- 6 — 1¼″ x 3″ 28-ga. galv. sheet metal tabs

TOP
- No frame—Lace wire netting to sides, back, and funnel with galv. stove wire

BOTTOM
- 2 — 120″ x 2″ x 2″ fir
- 4 — 70″ x 2″ x 2″ fir
- 1 — 72″ x 48″ 26-ga. galv. sheet metal for bait pan
- 2 — 10″ x 12″ shelf braces
- 6 — 2¼″ x 3/16″ stove bolts
- 6 — 1″ carter keys
- 2 — 54″ lengths of No. 12 galv. smooth wire
- 10 — 1¼″ x 3″ 28-ga. galv. sheet metal tabs

DIP GATE
- 4 — 68″ x 2″ x 2″ fir
- 3 — 24″ x 2″ x 2″ fir
- 2 — 16″ x 2″ x 2″ fir
- 20 — 1¼″ x 3″ 28-ga. galv. sheet metal tabs

ADDITIONAL MATERIAL NEEDED FOR FINISHING TRAP

Approximately 71 linear feet of 36-inch wide, 1½-inch mesh, 16 or 17 ga. galv. wire netting for top, bottom, sides, funnel, and end.

Two pieces of ¼-inch hardware cloth needed to cover dip gate, one 68″ x 26″ and one 68″ x 18″.

One 18″ x 69″ piece of 1″ x 2″ weld wire for partial partition, and one ¼″ x 76″ iron rod to brace lower edge of partial partition.

One 22″ x 36″ piece of 1″ x 2″ weld wire door for removing ducks from lifting gate.

One 16″ x 10″ piece of 1″ x 2″ weld wire for duck escape door.

Four 2″ x 8″ pieces of rubber impregnated canvas belting or other hinge material that will not bind with rust.

About 1 pound of 1-inch box nails and 1 pound of wire staples, two 1-inch pulleys, 18 feet of ¼″ rope, and a roll of galv. stove wire.

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## THE USE OF LIVESTOCK PASTURES IN SOUTHEASTERN WATERFOWL MANAGEMENT

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The problem of providing sufficient food for wintering waterfowl concentrations is the major one confronting those interested in southeastern waterfowl management. Livestock pastures can be made to contribute to this program. As with hay crops, pastures can never furnish the quantity of highly nutritious food possible through row cropping, but land suited only to pasturing is often available or the local economy may require that a portion of the land be devoted to this purpose. Pastures will be given only limited usage by ducks and coots, but, properly handled, will be heavily used by all species of geese.

Material for this paper was procured mainly from southeastern waterfowl refuges administered by the U. S. Fish and Wildlife Service, notably the Wheeler Refuge in Alabama, the Tennessee Refuge in Tennessee, the Kentucky Woodlands Refuge in Kentucky, and the Santee Refuge in South Carolina. Some information has come from state-managed public hunting grounds and refuges in the southeast and from observations on private land. Pas-

tures concerned are used primarily for cattle. Geese show little or no reluctance to feeding in company with domestic stock. The harvesting of crops through foraging livestock, while a valuable management practice, is not considered within the scope of this paper.

Generally, wild pastures are of little value for waterfowl use. Salt and fresh water marsh lands along the Atlantic and Gulf coasts are sometimes improved for waterfowl use by limited grazing or a combination of burning and grazing. Management of marsh lands by grazing for waterfowl involves problems outside the scope of this discussion. Upland wild pastures are generally worthless for waterfowl use.

Upland or inland pastures should be large enough to give feeding birds a feeling of safety and should be kept free of weeds, brush, and other undesirable cover. They should be located in reasonable proximity to water and should be seeded, limed, fertilized, and treated in accordance with the latest and best local practices.

The only pasture species worth considering for waterfowl management are those remaining green throughout winter. Both annuals and perennials, planted either as mixtures or as pure stands, can be used. The use of annuals to furnish winter pasture is common in many pasts of the southeast. Of these either the common or reseeding varieties of crimson clover are most desirable from both pasture and goose browse viewpoints. Ryegrass, wheat, oats, rye, and barley are frequently used fro winter pasture and furnish much goose forage. Button clover is coming into increasing use as a pasture annual and is given at least limited use by geese. Caley peas are occasionally used for pasture in some parts of the south, but are seldom used by geese and cannot be considered to have any real importance in a waterfowl program.

Among the perennials, alfalfa, frequently used for both hay and pasture, furnishes preferred browse. The fescues, including Kentucky 31, Aldous, and Alta, all provide good goose browse, although recent research casts some doubt as to their nutritive value. Other perennials used often in permanent pasture mixtures and subject to good goose usage include red top, orchard grass, blue grass, timothy, and white Dutch and ladino clovers.

Pastures are often established on land too wet for row cropping. Where wet lands are concerned, the fescues, red top, ryegrass, orchard grass, and ladino clover are least subject to water damage. Where concentrations of geese can be expected, early sowing is desirable in order to permit plants to be well rooted before birds arrive, thus helping prevent damage. Oversowing of crimson clover or ryegrass on Bermuda sod or pastures that have deteriorated will improve these for both cattle and geese.

Where perennials are concerned, goose usage is often heavy on first year plantings but declines as sod becomes older and tougher. The key to high waterfowl usage on permanent sods is to keep growth short and succulent. This can best be done by heavy grazing in fall and winter, almost to the point of overgrazing, so that only the tender, new growth, pushing through during periods of mild weather is available to the birds.

In addition to utilizing land unsuited to row crops, proper pasturing can make other contributions to a waterfowl management program. Since a balanced waterfowl program should provide both mature seed or grain and green browse, the production of browse through pasture, on land suited only to this purpose, will allow full use of row crop land for corn and other hard seed crops. Pasture can often be used to increase the desirability of row crop fields for waterfowl use by keeping adjacent non-row crop land in an open condition. It is a means of holding row crop land in stand-by condition at times when the demand for row crop rental is low, and is valuable in a crop rotation schedule. Even on non-refuge land there is no conflict with anti-baiting regulations. It should be remembered that this paper deals primarily with the southeast, where waterfowl nesting is not a significant factor, and that waterfowl show marked local food preferences.

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# A TECHNIQUE FOR BLEEDING NESTLING BIRDS BY CARDIAC PUNCTURE FOR VIRAL STUDIES

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Investigations on equine encephalomyelitis to determine natural animal reservoirs necessitated the taking of a large number of blood samples from very young birds as well as taking subsequent samples at five-day intervals or more from the same nestlings whenever time and opportunity permitted. To accomplish this, a technique was devised by which young birds could be bled at the nest with a minimum of bird loss. This paper describes the techniques used in obtaining blood samples for virus studies over a three-year period in Kansas and Colorado.

Field sampling equipment consisted of a supply of No. 12 or slightly larger Kraft paper bags for holding young birds and keeping those already bled separate from those to be bled during sampling activities; a supply of sterile 1- or 2-c.c. hypodermic syringes (the writer preferred using a 2-c.c. syringe when bloods from several birds in a nest were to be pooled); sterile 1-inch, 27-gauge needles; small (10-c.c.) serum bottles with 10% rabbit serum in buffered saline diluting fluid;[1] a bottle of 70% alcohol; tightly corked sterile 10 x 75 m.m. soft glass tubes with adhesive tape labels, for blood samples; and a pint thermos flask partly filled with wet ice for immediate refrigeration of blood samples and for carrying these to the laboratory. A bottle of clean water for rinsing syringes and needles after use facilitated later cleaning of this equipment. A supply of Fish and Wildlife Service bands was carried for marking the birds when possible.

The young birds were removed from a nest and placed in a Kraft paper bag. To prepare the syringe for procuring the blood sample, 0.1 c.c. or 0.2 c.c. diluting fluid was drawn into it. This enabled the operator to obtain better initial suction with the syringe and to waste less blood when only 0.1 c.c. or 0.2 c.c. was taken from a nestling.

A young bird to be sampled was then placed on its back in the left hand, with its head toward the finger-tips. The neck of the bird was placed between index and middle fingers and the head pulled back slightly. Legs and posterior part of the bird were held down between little finger and thumb, which tended to arch the breast of the bird upwards for easier needle penetration. The ring finger was used to hold down the left wing when it was of any size and tended to get in the way. The operator worked from a sitting or kneeling position and steadied his hand holding bird by resting it on his knee.

Location of the heart was facilitated by feeling for strongest point of heartbeat. The needle was inserted at about a 30-degree angle on left side below the tip of the sternal keel and at back edge of the ribs. The needle was pointed downward slightly toward the bird's vertebral column (about 10 to 15 degrees), and directed at heartbeat, usually toward the mid-part of the sternal line (Fig. 1). Plunger action was started as soon as the needle penetrated the chest wall. This provided opportunity to take up blood as soon as the heart was entered. The barrel of the syringe was steadied between tips of thumb and little finger holding bird while the plunger was manipulated with the right hand. Penetration was made steadily and slowly permitting sufficient time for blood to show in the tip of syringe when the heart was penetrated and before the needle was pushed through it. Approximately 0.1 c.c. of blood was taken from each very young and small nestling and slightly more from larger and older ones. The blood was immediately placed into a sterile tube, labeled and placed in the thermos of wet ice. Birds were returned to the nest after nestling ages and other pertinent data were recorded.

[1] Formula composed of 10 ml. of rabbit serum in 90 ml. of Sorensen's buffered saline. Rabbit serum is inactivated at 56°C. for 30 minutes before adding to buffered saline solution.

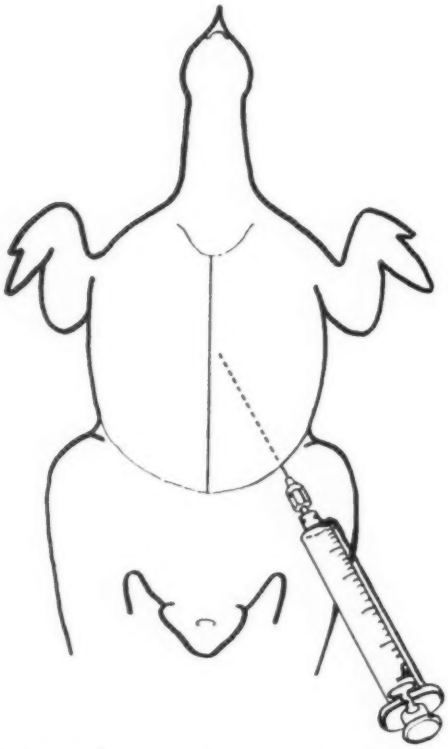

FIG. 1. Diagrammatic illustration of hypodermic needle inserted into nestling bird.

Revisits to bled nestlings demonstrated that a minimum loss of life resulted from these activities. Juvenile song-birds from 4 to 30 days of age were bled as many as four times by the above methods (Table 1). They showed little sign of mechanical or shock injury, and deaths from blood sampling activities were estimated at about 2 per cent. In arriving at this low percentage loss estimate, consideration was also given to the possibilities of predation and other natural factors causing losses. Some young birds escaped at or just before revisits to nests.

With the above methods, 940 nestlings in 304 broods (24 species) were bled in Bourbon County, Kansas in 1949, 1,325 nestlings in 503 broods (20 species) in Colorado in 1950, and 1,136 nestlings in 483 broods (13 species) during 1951 in Colorado.

It was found necessary to take blood samples from the wing vein (brachial vein) of mourning doves and pigeons. These birds did not withstand cardiac punctures very well and when a relatively high mortality was noted in the first three or four lots of nestlings bled, sampling technique for these birds was changed. Very little mortality from the wing bleeding method occurred (Table 1).

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TABLE 1.—NESTLING BIRDS BLED FOR VIRUS STUDIES IN COLORADO DURING 1951

| | Pigeons and Doves | | Other Birds | |
|---|---|---|---|---|
| | Broods Sampled | Nestlings Bled | Broods Sampled | Nestlings Bled |
| Bled 1st time | 219 | 354 | 267 | 782 |
| Bled 2nd time | 96 | 154 | 39 | 107 |
| Bled 3rd time | 26 | 41 | 3 | 11 |
| Bled 4th time | 6 | 9 | 1 | 2 |

## A METHOD OF STORING AND HANDLING SHRUB LESPEDEZA

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The farm-game program for Delaware has raised *Lespedeza bicolor* in a project nursery for the past three years. The common strain and strain 101 are used. These plants are grown to a size for setting out with a transplanter or tree planter.

It is necessary to have plants available for early setting out because soil is often ready during late March or early April, thus nursery stock has to be lifted the previous fall. Various methods of keeping plants in storage have been tried. For the first two years, plants were dug in the fall by a nursery-type lifter and were stored in the basement of an old unoccupied farm house. This basement had an earth floor, and was well ventilated and cool. Plants were bundled and stacked between layers of hair-cap moss which was kept moist. This means of storage did not give completely satisfactory results because some plants would heat and rot.

The 1952 nursery stock was handled in a different manner with better results. As usual, stock was lifted during the fall, but instead of being stored in moss, the bundled plants were merely piled in the same basement. Weather conditions did not permit a complete harvest of the nursery stock, so it was not until April 1, 1953 that the remainder of the plants were lifted. These too were bundled and piled in the basement to await planting.

Plants which were stored in a dry condition, completely dormant, remained in an excellent state of preservation. Tops were cut from the plants at the time of storage and no moss or moisture were used.

Another factor of interest was a method of handling plants from the time they were taken from storage until planting. It was often necessary that farm-game personnel have on hand enough plants for several days planting supply. Plants which were heeled-in any length of time began growing. When planted in the field, the second shock of moving caused high mortality. The best method found was to keep plants dry rather than heeled-in. Often plants were hauled around in the rear of a pickup truck for as long as two weeks without apparent damage.

It appears from experience that shrub lespedeza plants can be stored and transported in a dry state rather than with the use of moss or water. Heeling-in of plants will break the dormancy; this is not a desirable situation until the plant has been set out in its permanent location.

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## METHODS OF MARKING WILD RABBITS

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### INTRODUCTION

To permit identification at recapture, small mammals have been marked in various ways. Leg rings have been used by Kalabukhov and Raevskii (1935), Chitty (1937), Aldous (1946) and others, tattooing by Allen (1939) and ear tags by Andersen (1951). Individual wild rats have been identified from a hide at close quarters when marked by a fur clipping and depilatory technique (Chitty and Shorten 1946; Thompson 1948), but the marks need to be renewed after the fur has grown for a few weeks. To identify rabbits from a distance without catching them it is best to attach coloured or numbered tags to the ears, which

are frequently erected and faced forwards. Niethammer (1937), Southern (1940), Trippensee (1941), Hosley (1942) and Tyndale-Biscoe (1953) have all used this technique. Southern, using numbered tags, implied that individual rabbits could be identified with a telescope at 100 yards, while Trippensee, using combinations of colours and 8x binoculars, claimed only 20 yards.

In the course of a study on the effect of grazing of rabbits (*Oryctolagus cuniculus* L.) on sheep pastures (Thompson 1953) in 1950–51, a ¾-acre warren was enclosed with rabbit-proof wire netting and the rabbits marked and caught from time to time in live traps, gin traps and by ferreting. Different marking techniques were tried during the experiment.

### USE OF PLASTIC DISCS

Southern's method was used, except that the paper-clip-like fastener securing the plastic disc [1] to the rabbit's ear was of stainless steel, nickel being unobtainable. The ¾″ diameter numbered disc was found to be more readily visible when placed inside the ear (Southern's and Trippensee's were put inside and Tyndale-Biscoe's outside) and a ½″ diameter plastic backing disc or washer was fitted outside. When recaught soon afterwards, several of the first rabbits to be marked showed suppuration between the disc and washer. These were removed and fitted more loosely so that there was no pressure on the ear. Despite this, many recaptured rabbits were found to have lost their discs and others were seen with holes in their ears; several discs, complete with washer and clip, were picked up on the rabbit warren

The results are summarized as follows: 4 rabbits are known to have carried tags until they died (212, 328, 356 and 374 days after insertion); 31 rabbits were carrying tags when trapped for the last time (1–228 days, average 31); 32 rabbits are known to have lost their tags in 3 to 357 days (average 82); 24 rabbits are known to have lost their tags (tag-hole in ear but, not being tattooed, unidentifiable); 51 rabbits were not caught again after insertion of tags.

Black numerals ½″ high engraved on white discs (Fig. 1) were used for the first hundred rabbits and were found to be more readily visible from a distance than the second series of black on yellow. Visibility also varied with the rabbits' movements. Using 8x binoculars, it was always possible to see up to 100 yards whether a stationary rabbit was tagged or not, but the number could not easily be distinguished beyond 20 yards, and only then if the rabbit was holding its ears still, at least partly facing the observer and in good light. Using a pancratic telescope with a 2″ objective, numbers could not be identified with certainty beyond 40 to 60 yards and then only under good conditions. During three months observations, 55 rabbits out of 112 marked were identified by telescope. This type of marker, particularly if used with a more efficient attachment (such as Tyndale-Biscoe's rivet), allows information on individual behaviour to be collected (Southern, 1948).

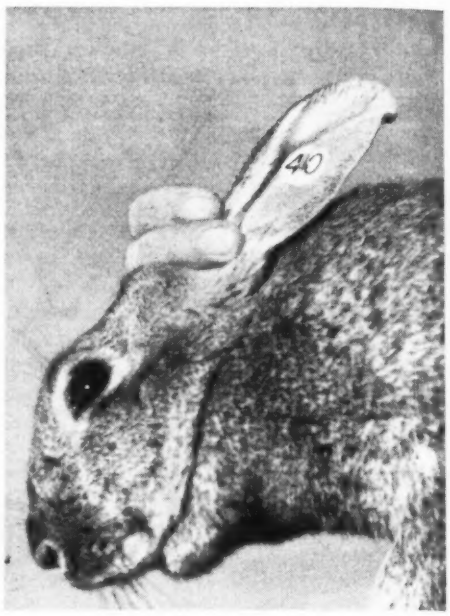


FIG. 1. Plastic disc in place.

### USE OF CHICK TABS

These aluminum tabs [2] are attached to

[1] Supplied by U. K. Plastics, Kingston-by-Pass, Surbiton, England.

[2] Supplied by T. E. L. Startin, 106, Emily Street, Birmingham, England.

FIG. 2. Tattooed numerals.

rabbits' ears by a curved safety pin and were used with success in Wales by Phillips (1952). The tabs are ½″ square and can be obtained plain or with engraved numbers; they are of the same weight as the plastic discs (0.7g.). For sight observations, black numbers painted on white ground were found to be satisfactory although, being smaller, tabs did not show up quite so well as plastic discs. There were only two cases of suppuration around pin holes and these cleared up of their own accord.

Results in summary are: 54 rabbits are known to have carried tabs until they died (1–311 days after insertion, average 129 days); 32 rabbits were carrying tabs when trapped for the last time (2–73 days, average 34); 2 rabbits are known to have lost their tabs (one after 29 days and the other between 60 and 290 days); 12 rabbits were not caught again after insertion of tabs.

## TATTOOING

When it was found that a considerable number of rabbits were losing their plastic discs, it was decided to tattoo the untagged ear (right ear of does and left ear of bucks) of each rabbit subsequently caught. The same numbers, 0–99, as those on the white discs were used. The numbers on the yellow discs began again at 0 while the tattoos continued from 100 onwards. Chick tabs, also numbered 0–99 were given tattoo numbers 200–299. An ordinary sheep tattooing outfit was used, with numerals ¼″ x ¼″ and even the small ear of an 8 oz. (3–4 week old) rabbit will accommodate three of these large numerals. A smaller instrument has now been made to our specifications.[3] The process of tattooing does not cause the rabbit any marked discomfort. For convenience of handling, weighing, attaching tags and tattooing, each rabbit was secured in a small (sandbag) sack. Near one corner of the sack were two holes through which the rabbit's ears could be protruded. With the exception of three, whose ears were subsequently badly torn or scratched, all 167 tattooed rabbits retained legible numbers until their death or disappearance over a period of 508 days.

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## FURTHER STUDIES OF BOB-WHITE MOBILITY IN CENTRAL MISSOURI[1]

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Because of differing results of mobility studies conducted at widely separated points in the bob-white's (*Colinus virginianus*) range, and because of lack of specific information on this subject under Missouri conditions, a series of investigations on mobility of wild bobwhites was initiated by the Missouri Cooperative Wildlife Research Unit. First results of this study were reported by Murphy and Baskett (1952). (Bobwhite mobility in central Missouri, Jour. Wildl. Mgt. **16**: 498-510, 1952). The investigation reported here, the second of the series, was designed to supplement the first.

The studies were made on and in the vicinity of the Ashland Wildlife Research Area in Boone County, central Missouri. This area comprises 2,240 acres of abandoned farm land and second growth oak-hickory woodland; approximately one-third of the acreage consists of abandoned fields along ridges, and other openings which are frequented by quail and are widely distributed through the area.

Quail densities on the entire Ashland Area averaged about one bird per nine acres in late winter. The open north-central portion carried somewhat higher densities, as did neighboring farmland to the north and west, where most off-area trapping was conducted. The land south and east of the Ashland Area is mostly wooded, and supported fewer quail.

Data were secured by trapping and banding wild bob-whites. Materials used in the two studies were similar: "cock-and-hen" traps baited with grain in fall and winter, and furnished with decoy females in spring and summer. Quail were banded with numbered aluminum bands, but colored plastic leg bands and neck markers were used as supplementary marking systems. Procedures were also similar, but in the present study, the Ashland Area was trapped somewhat less intensively, and the surroundings more intensively, than in the previous investigation. The studies had in common an inadequate measure of egress.

For detailed description of the area, of materials and procedures, and for a review of pertinent literature, the reader is referred to the paper by Murphy and Baskett (*op. cit.*).

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri cooperating. The writer is indebted to T. S. Baskett who directed the research, and to D. A. Murphy, W. H. Elder, T. G. Scott, and P. C. Smith for advice and assistance.

The present study was carried out during the period June 1, 1951, to June 1, 1952, immediately following the first study. During this period, 300 quail were trapped at least once; 267 of these were unbanded but 33 were birds first trapped by Murphy and Baskett. One hundred and forty-five of the 300 quail were trapped a total of 596 times. Additional data were provided by nine recoveries of banded quail during the hunting seasons of 1951 and 1952.

From June 1 to August 1, 1951, movement data were obtained for 27 birds; most were males and many were thought to be unmated. Summer movement data are summarized in Table 1, together with similar data from the previous study, and with combined data from both studies. It can be seen from Table 1 that a high percentage of the birds in each study were recaptured no farther than a half mile from the first summer trap sites, and pooled data from both studies show that the summer movement of 52 of 59 quail, or 88 per cent, apparently carried them no farther than a half-mile from first summer trap sites.

TABLE 1.—MAXIMUM DISTANCES TRAVELLED DURING SUMMER FROM FIRST SUMMER TRAP SITES, AS INDICATED BY RETRAPPING

(In parentheses: Numbers of records of movement for birds in each category)

| Maximum distance travelled (miles) | Birds Moving This Distance: Present Study | Murphy & Baskett | Totals |
|---|---|---|---|
| 0 to 1/4, incl..... | 18 (23) | 11 (33) | 29 (56) |
| Over 1/4 to 1/2.... | 6 (23) | 17 (64) | 23 (87) |
| Over 1/2 to 3/4.... | 2 (7) | 2 (13) | 4 (20) |
| Over 3/4 to 1..... | 1 (1) | 1 (7) | 2 (8) |
| Over 1..... | ..... | 1 (2) | 1 (2) |

The pooled data support Murphy and Baskett's conclusion that summer is a period of relatively low mobility for central Missouri bob-whites, even though most data were probably furnished by unmated males. Evidence of another sort supporting this conclusion was provided in the present study by the fact that there was little ingress during the summer. Only five of 31 birds trapped on the Ashland Area proper during the period June 1 to August 15 could possibly have moved in during this period, and four of these may have been present on the area earlier but avoided capture. One definitely did move in.

During the fall shuffle, combining of broods to form coveys was demonstrated in both the previous study and in this one. But during neither study was greatly increased movement during fall detected. Murphy and Baskett did find that eighteen adults yielding records of movement between summer and winter were somewhat more mobile during the elapsed period than in summer. In both studies, movements were performed by a few coveys which carried them away from the first fall trap sites, to which they did not return. The fall data in both studies were weakened by the presence of large numbers of unmarked young birds whose places of origin were unknown. Movement of quail during the fall shuffle is deserving of further study, and employment of marking systems for birds too young to be banded would be of considerable aid.

Banded quail were extremely sedentary during the entire fall and winter period of the present study. Of 79 birds trapped and recaptured from August 15, 1951, to April 1, 1952, none were taken farther than a half-mile from the first fall or winter trap site. These results agree in general with those of Murphy and Baskett, except that they detected increased movement in late winter, prior to covey break-up. In the present study, which was less intensive, such movement was not noted.

Dispersal data were acquired for the spring season of 1952, and some 1951 data not available to Murphy and Baskett were also employed; a total of 48 banded birds provided these data. In addition, 22 unbanded quail were trapped on the study area in the spring of 1952. Spring dispersal began about the first of April, 1952, and was completed by June 1.

Spring dispersal data are shown in Table 2,

TABLE 2.—SPRING DISPERSAL

| Distance in miles between last winter trap site and farthest spring or first summer trap site. | Birds moving this distance: Present Study | Murphy & Baskett | Combined Data |
|---|---|---|---|
| 0 to 1/4, incl..... | 16 | 24 | 40 |
| Over 1/4 to 1/2..... | 17 | 17 | 34 |
| Over 1/2 to 3/4..... | 9 | 9 | 18 |
| Over 3/4 to 1..... | 3 | 0 | 3 |
| Over 1..... | 3 | 4 | 7 |

together with data from the previous study, and with combined data from both studies. Combined data show 74 of 102 birds, or 73 per cent, apparently dispersing no farther during spring than a half-mile from the last winter trap site. This figure, 73 per cent, can be compared with figure of 88 per cent obtained from combined data for summer movements, indicating somewhat greater movement in spring than in summer. Without doubt, movement in spring exceeded that in summer, for there was considerable evidence of ingress during spring. Of 52 quail trapped on the study area in the spring of 1952, 30 were banded birds which had been there during the previous winter. Most of the remaining 22 unbanded birds represented ingress, for about 85 per cent of birds resident on the area in winter were banded. Murphy and Baskett reported similarly great ingress during spring; in their study 28 of the 60 birds caught in spring were unbanded.

Nine records of movement were obtained during this study through hunting recoveries. Seven of the nine records were for birds which probably at least began their movement in spring, for they were last trapped on the area in late winter or spring. They were shot during the following fall at distances ranging from three-fourths of a mile to twelve miles from the last trap sites. Since the Ashland Area is a refuge, all these recoveries were made outside it.

Murphy and Baskett summarized extreme movements from banding sites for quail giving records at least during spring and fall; they considered these records to give the best information available on the lifetime cruising radius of banded quail. Of 45 birds, 29, or 64 per cent, gave all returns within a half-mile of the banding site. In the present study, similar information was derived by tabulating greatest distances moved from banding points by all birds giving records during two or more seasons. Fall and winter were considered as one season. It was found that 42 of 69 birds, or 61 per cent, were retrapped or recovered no farther than a half-mile from the banding point.

Nevertheless, nearly half the birds for which suitable data were obtained moved more than a half-mile from the banding point, and many others moved nearly that distance. These facts suggest once more the importance of managing quail in larger land units than the individual farm, which in Missouri is often no more than a half-mile in greatest dimension. If the goal of a management program is well-rounded environmental improvement effective during all seasons, rather than seasonal "baiting-in," then it seems wise for the manager to encourage some quail management on each of several adjoining farms rather than to concentrate efforts on intensive management of scattered single farms.

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## AVIAN MALARIA IN RELATION TO SURVIVAL AND GROWTH OF A GROUP OF YOUNG GAMBEL'S QUAIL IN CAPTIVITY

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During the period 1946-49 the New Mexico Department of Game and Fish carried on a statewide investigation [1] of quail malaria in New Mexico, primarily with reference to Gambel's and scaled quail. The main results of this study have been reported by Campbell and Lee (1953), but the following details have not previously been reported in full.

[1] Federal Aid in Wildlife Restoration Project W-41-R.

At La Joya State Game Refuge in central New Mexico, a covered pen of one-inch mesh poultry wire was constructed to serve as a trap for capturing whole coveys of quail and holding them for observation and processing. This pen was 6 feet high and measured 12 x 48 feet. It contained and was completely surrounded by a good deal of natural brushy cover. When in use as a trap or holding pen it was kept supplied with water, poultry scratch and oyster shell grit. "Chick Startena"

and fresh lettuce were also supplied when young quail were held in the pen for more than a day or two. It had been determined previously that the Gambel's quail population inhabiting the La Joya Refuge was heavily infected with malaria.

On July 19, 1949, a mixed group of 13 young, malaria-negative Gambel's quail, *Lophortyx g. gambeli* Gambel, probably ranging from about 3 to 5 weeks old, were captured in the pen along with various other quail. These young birds and one adult female Gambel's quail, which at once adopted them all, were retained in the pen for several weeks and periodically examined. Four of the survivors were later taken to the Game Department laboratory at the University of New Mexico for further checking and eventual autopsy. As many (presumably malarious) quail as possible were regularly attracted to the immediate vicinity of the pen by keeping the area just outside baited with poultry scratch. All captives were periodically weighed to the nearest gram. Weights thus obtained were "total weights" (Westerskov, 1953). At each weighing thin blood smears were made by the usual method, using peripheral blood obtained from small veins on the underside of the wing. After drying, these smears were taken into the laboratory, where they were fixed in absolute methyl alcohol, stained with Field's eosin-methylene blue, and examined under oil at 970X for malarial parasites. No slide was listed as negative until at least 150 fields had been examined. On this series of slides at the stated magnification with the microscope equipment used, 150 fields would include, on the average, about 26,250 r.b.c. When positive slides were found they were rated for degree of parasitemia. These ranged from approximately 0.6 to 1370 infected r.b.c. per 10,000 r.b.c., the mean figure for this series of slides being about 119. Approximately 70 per cent of these slides fall into the classification of from 0.6 to 114 infected r.b.c. per 10,000 r.b.c., while about 90 per cent are involved when we extend the coverage to include 228 infected r.b.c. per 10,000 r.b.c.

Table 1 details some of the results obtained with respect to bird weights and presence or absence of infection. Only one of 13 young Gambel's quail failed to develop a demonstrable malarial infection, and this one was lost to predation midway in the study. Malarial infections were due to *Haemoproteus lophortyx* O'Roke and *Plasmodium* sp. (probably that known as strain 50-A of the American Society of Parasitologists). Three of the 12 infected young birds (band nos. 6545, 6547 and 6552) either had mixed infections or harbored the two species of parasites at different times. There was an evident tendency for highest

TABLE 1.—WEIGHT CHANGES AND MALARIAL PARASITEMIA IN 14 CAPTIVE GAMBEL'S QUAIL

| Date | July 20 | | July 30 | | Aug. 5 | | Aug. 12 | | Sept. 2 | | Sept. 9 | | Oct. 6 | | Oct. 31 | | Dec. 1 | | Dec. 9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wt.[1] | Inf.[2] | Wt. | Inf. | Wt. | Inf. | Wt. | Inf. | Wt. | Inf. | Wt. | Inf. | Wt. | Inf. | Wt. | Inf. | Wt. | Inf. | Wt. | Inf. |
| Males | | | | | | | | | | | | | | | | | | | | |
| 6538 .. | 45 | − | 55 | − | 70 | − | 87 | − | 119 | − | 134 | − | ..... | | ..... | | ..... | | ..... | |
| 6539 .. | 39 | − | 47 | − | 57 | − | 70 | − | 95 | + | 108 | + | ..... | | ..... | | ..... | | ..... | |
| 6543 .. | 45 | − | 59 | − | 72 | − | 82 | − | 114 | − | 127 | − | 167 | − | 165 | + | 173 | + | 171 | ? |
| 6550 .. | 44 | − | 53 | − | 57 | − | 84 | − | 113 | − | 127 | + | ..... | | ..... | | ..... | | ..... | |
| 6551 .. | 34 | − | 44 | − | 58 | − | 74 | − | 97 | + | 117 | + | 155 | + | ..... | | ..... | | ..... | |
| 6552 .. | 41 | − | 47 | − | 59 | + | 72 | + | 93 | + | 96 | + | 137 | + | ..... | | ..... | | ..... | |
| 6553 .. | 40 | − | 46 | − | 57 | + | 71 | + | 104 | + | 120 | + | ..... | | ..... | | ..... | | ..... | |
| 6554 .. | 34 | − | 42 | − | 53 | − | 67 | − | 95 | − | 109 | − | 137 | − | 133 | + | 139 | + | 135 | + |
| 6556 .. | 54 | − | 66 | − | 77 | − | 92 | − | 124 | + | 134 | + | 149 | + | ..... | | ..... | | ..... | |
| Females | | | | | | | | | | | | | | | | | | | | |
| 6537 .. | 38 | − | 50 | − | 63 | − | 77 | − | 107 | − | 122 | − | 142 | + | ..... | | ..... | | ..... | |
| 6545 .. | 43 | − | 56 | ? | 64 | − | 77 | + | 112 | + | 122 | ? | 148 | + | 136 | + | 151 | + | 147 | + |
| 6547 .. | 51 | − | 60 | − | 70 | − | 83 | − | 111 | + | 133 | + | 158 | + | 152 | + | 162 | + | 167 | + |
| 6548 .. | 32 | − | 40 | − | 51 | − | 68 | − | 89 | − | 105 | − | 137 | + | ..... | | ..... | | ..... | |
| Adult | 169 | + | 166 | + | 168 | + | 171 | + | 168 | + | 171 | + | 173 | + | ..... | | ..... | | ..... | |

[1] Weights in grams.

[2] Parasitemia with *Haemoproteus* or *Plasmodium*.

parasitemias to occur during September and October and to subside thereafter. Even the adult bird showed a slight rise in parasitemia at the September 9 interval, temporarily interrupting the even tenor of its apparently typical light-chronic infection (O'Roke, 1930).

As a supplementary aid in the interpretation of Table 1, the following notes are given: Birds numbered 6538, 6539, 6550 and 6553 were almost certainly lost, not to malaria but to snake predation; birds numbered 6551, 6552, 6556, 6537 and 6548 were released in apparently good condition on October 9; birds numbered 6543, 6554, 6545 and 6547 were held in laboratory cages from October 6 to December 13, and during all that time they appeared to be in excellent health despite their malaria. At autopsy, breast contours of all four birds were found to be normal even after long confinement in the outdoor pen and laboratory cages. Average weight of the four birds on December 9 was 155 grams, which compares very favorably with the average weight of 152.9 grams determined by Campbell and Lee (1953) for 30 non-infected Gambel's quail of the same age class at La Joya.

On December 13 the four laboratory birds were killed and autopsied, with the following results: No. 6543. Gross appearance of all viscera normal. Spleen 6x4 mm.; No. 6554. Spleen normal in color but enlarged (8x5 mm.). Gross appearance of all other viscera normal; No. 6545. Spleen black and enlarged (9x6 mm.). Liver pale with red streaks. Gross appearance of all other viscera normal; No. 6547. Spleen black and enlarged (9x6 mm.). Gross appearance of all other viscera normal.

Evidence here presented is interpreted to mean that infections caused by the two malarial organisms probably had little if any consistently detrimental influence on survival and growth of 12 infected young Gambel's quail. Results appear to be in substantial agreement with the general conclusions drawn for Gambel's quail populations in the main study referred to above.

This was the only group of infected Gambel's quail which could be carefully observed from the very young stage through to young adulthood during the study mentioned.

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## THE FECAL PELLET GROUP DEPOSITION RATE OF DOMESTIC SHEEP

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Ever since the fecal pellet group count method was first applied to deer census studies by Bennett, *et al.* (1940) and was further elaborated by Rasmussen and Doman (1943), and McCain (1948), it has found considerable use among game technicians.

On ranges where there is dual use by deer and domestic sheep, difficulty often arises in separating the pellet groups of the two animals. Therefore it was considered worth-while to determine the pellet group deposition rate for domestic sheep so that where their numbers and duration of stay on a given range were known, a fraction of the total pellet group count could be assigned to them.

Sheep pellet counts were carried out at the

Hopland Field Station of the University of California College of Agriculture. The first count was made in a field of grain stubble measuring 3.124 acres where 32 buck sheep were confined for 20 days from June 13 until July 3, 1952. In addition to the feed they could pick up from the stubble, they were supplied with oat and alfalfa hay. Thus, except for a small amount of summer-growing annual weeds, they were entirely on dry feed.

After the 20-day period, pellet groups were counted on six .01-acre strip plots distributed at random over the field. Each plot measured 6 feet by 72.6 feet.

The total pellet group count for the six plots was 163. At this rate there would have been 8486.9 groups on the entire field, or 265.2 groups per sheep, or 13.26 groups per sheep day.

In order to determine whether there was material difference in the pellet deposition rate when sheep were on green feed, two yearling ewes were confined in separate enclosures for 24 hours, February 19–20, 1953. There was sufficient green grass growing in these enclosures to provide a normal forage intake.

Fifteen pellet groups were counted in one enclosure and sixteen in the other.

From these data, it would appear that the pellet group deposition rate for domestic sheep is slightly above the 12.7 figure which has been stated for deer. Likewise, even though the sample is small, the rate was higher when sheep were on green feed.

Unpublished data gathered by Arthur D. Smith of the Utah State Agricultural College indicate that there may be similar seasonal differences in the deer pellet deposition rate. A letter from Smith shows winter counts for penned deer averaging 11.2 groups per day and summer counts 13.7 per day.

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## GAME FARM PHEASANT RETURNS TO THE HUNTERS' BAG WEBER COUNTY, UTAH, 1946–1951

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The role which game-farm-reared pheasants play in stocking pheasant habitat and in the pheasant harvest has been the subject of much study, discussion and speculation during the past decade.

The objectives of the present study were to determine: (1) effect which hunting pressures play on the return of game farm birds released in good habitat which already had a high pheasant population, (2) hunter removal of wild pheasants from an area having heavy hunting pressure and a large population of game farm birds.

The study was initiated in the summer of 1946 and continued each summer until terminated in the fall of 1951.

### DESCRIPTION OF THE AREA

The West Warren Pheasant Experimental Area, located about 4 miles west of Warren, Weber County, north-central Utah, is an isolated area of irrigated land surrounded by non-cultivated lands.

In 1950 the principal crops of the area were alfalfa (41.8 per cent), grain (7.9 per cent), corn (1.9 per cent) and plowed lands (36.8 per cent). Within the area of cultivation are

[1] U. S. Fish and Wildlife Service, Utah State Department of Fish and Game, Wildlife Management Institute, Utah State Agricultural College, cooperating.

marshes (3.4 per cent) and non-cultivated grazed lands (8.2 per cent). About 257 acres of land are irrigated and cropped and 1710 acres consist of pasture and waste land.

### STUDY TECHNIQUES

Approximately 100 male birds were released yearly, except for 268 birds in 1946. The birds were selected at random from thousands raised at the Springville Game Farm. At intervals of two weeks, beginning about the first week of August, 20 males were taken from the farm for release on the area. The fifth or last release was in October a few days to a month before the hunting season. One group of 44-week-old birds was released in the spring of 1946 (Table 1).

Birds of each age group were released all at once with no protection given them following their release. The same release site on the study area was not chosen for successive releases either within the same season or between the years.

With the exception of the 44-week-old birds released in 1946 the birds released each year all hatched at the same time. The largest number (180) were released at 6 weeks of age but in no age class were there fewer than 19 birds.

A checking station located on the only access road to the study area permitted a complete check on the birds removed during hunting seasons.

The pheasants were placed on the study area at the rate of 39 birds per 100 acres of cultivated land with the exception of the first year (1946) when the rate was one bird per cultivated acre. The pasture, marsh and waste study area increased the acreage per bird released, although no birds were observed and few were killed beyond the cultivated acreage.

### RESULTS

Total band returns: Of the 764 game farm pheasants released on the study area during the 6 years, 211 birds (27.6 per cent) are known to have been legally bagged. Some banded birds were reported in hunters' bags in areas not too distant from the experimental area which, when added to the number legally bagged on the area would slightly increase the percentage of returns.

Band returns by years: The highest return of game farm birds in hunters' bags was 46 per cent in 1947 and the lowest was 15 per cent in 1946. The 1946 releases were made in general of younger birds and farther in advance of hunting season than in other years. The year of highest returns of game-farm birds was not the year of highest kill of wild birds on the area (Table 2).

TABLE 1.—SUMMARY OF RETURNS OF BANDED MALE PHEASANTS AT THE WEST WARREN EXPERIMENTAL AREA, 1946–1951

| Age when released (weeks) | Number released | Return of banded birds | | Release made prior to hunting season (weeks) | Number released | Return of banded birds | |
|---|---|---|---|---|---|---|---|
| | | Number | Per cent | | | Number | Per cent |
| 5 | 40 | 10 | 25.0 | 31 | 19 | 2 | 10.5 |
| 6 | 120 | 23 | 19.2 | 15 | 39 | 11 | 28.2 |
| 7 | 90 | 26 | 28.9 | 14 | 40 | 9 | 22.5 |
| 8 | 90 | 13 | 14.4 | 13 | 60 | 15 | 25.0 |
| 9 | 108 | 25 | 23.1 | 12 | 160 | 36 | 22.5 |
| 10 | 58 | 18 | 31.0 | 11 | 50 | 12 | 24.0 |
| 12 | 60 | 21 | 35.0 | 10 | 108 | 27 | 25.0 |
| 14 | 59 | 17 | 28.8 | 9 | 20 | 8 | 40.0 |
| 15 | 20 | 8 | 40.0 | 8 | 60 | 15 | 25.0 |
| 16 | 40 | 15 | 37.5 | 6 | 79 | 30 | 37.9 |
| 18 | 40 | 24 | 60.0 | 4 | 20 | 8 | 40.0 |
| 24 | 20 | 9 | 45.0 | 3 | 20 | 8 | 40.0 |
| 44 | 19 | 2 | 10.5 | 0 | 40 | 24 | 60.0 |

TABLE 2.—RELEASE AND KILL DATA OF PHEASANTS ON THE WEST WARREN EXPERIMENTAL AREA, 1946–1951

| Year | Farm birds released | No. farm birds in hunters' bag | % of banded cocks killed | % banded birds in total kill | % of wild birds in total kill | No. of wild birds in hunters' bag | Total birds bagged |
|---|---|---|---|---|---|---|---|
| 1946..... | 268 | 40 | 14.9 | 17.8 | 82.2 | 185 | 225 |
| 1947..... | 100 | 46 | 46.0 | 23.3 | 76.7 | 152 | 198 |
| 1948..... | 99 | 35 | 35.3 | 14.2 | 85.8 | 212 | 247 |
| 1949..... | 99 | 30 | 30.3 | 17.3 | 82.7 | 143 | 173 |
| 1950..... | 100 | 28 | 28.0 | 16.0 | 34.0[1] | 140 | 168[1] |
| 1951..... | 98 | 32 | 32.7 | 23.0 | 77.0[2] | 99 | 131[2] |
| Total ..... | 764 | 211 | 27.6 | 18.2 | 80.5 | 931 | 1157 |

[1] 52 unmarked 8-week-old roosters released by local warden of which 7 were calculated to have been bagged but not included in tabulations.

[2] 60 unmarked 8-week-old roosters released by local warden of which 8 were calculated to have been bagged but not included in tabulations.

Band returns in relation to birds' age and length of time prior to hunting season: Highest returns, 60 per cent, were from birds which were released when they were 18 weeks old while lowest returns were from birds released at 44 weeks of age.

One-fourth or 25 per cent of the youngest group, 5-week-old birds, were returned to the hunters' bag. Forty-five and 60 per cent respectively of the 18- and 24-week-old birds were returned. Birds 44 weeks old at the time of release gave only a 10 per cent return. Other age-class releases varied in the 30 and 40 per cent range (Table 1).

In general, the returns of game-farm-reared pheasants increased as the release date approached the hunting season. Thus, birds released up to 4 weeks prior to the opening date of the season gave 40 to 60 per cent returns while less than 30 per cent of those released longer than 4 weeks before the season were returned (Table 1). One release of birds within a week of the season resulted in a 75 per cent return.

Birds released 31 weeks prior to the season showed the lowest returns, 10 per cent.

Loss of birds other than to hunting: It has long been known that many released game farm birds do not survive until the hunting season. In 1946 the release of 1300 game farm birds on 12 sites in Weber County was studied to determine the extent of the pre-hunting season mortality.

Dogs were the most destructive agent to the birds, accounting for 38 per cent of the observed mortality. Seventeen per cent of the mortality was due to hay mowers, 17 per cent to hawks, 13 per cent to cats, 3 per cent to skunks and 12 per cent was undetermined (Table 3). Thus, the losses of farm reared birds

TABLE 3.—CAUSES OF MORTALITY OF 107 GAME FARM PHEASANTS FOUND IN WEBER COUNTY, UTAH, 1946. BASED ON RELEASES OF 1300 BIRDS AUGUST 14, 1946

| Mortality Agent | Released birds found dead, Aug. 14–22 | Oct. 12 | Number | percent |
|---|---|---|---|---|
| Dogs | 40 | 1 | 41 | 38.32 |
| Hay Mower | 18 | – | 18 | 16.82 |
| Hawks* | 17 | 1 | 18 | 16.82 |
| Cats..... | 14 | – | 14 | 13.09 |
| Skunks | – | 3 | 3 | 2.80 |
| Unknown** | 12 | 1 | 13 | 12.15 |
| Total | 99 | 6 | 107 | 100.00 |

* Swainson, red-tailed, marsh, and sparrow hawks and short-eared and burrowing owls were in the study areas.

** No indication of violent death. Probably exposure, starvation, disease, etc.

prior to the hunting season may be a significant factor in the comparatively low returns of pheasants to the bag.

Hunting pressure and hunting success: A total of 931 wild birds is known to have been bagged on the study area during the 6 years which represents an average of 155 birds per year or an average of 59 birds per 100 acres of irrigated land.

Hunting pressure was extremely heavy. A total of 2230 hunters used the small study area during the five-year period 1946–1950, an average of 446 hunters per season (Table 4). Because of the small size of the area, hunters did not remain long; they spent less than one hour each on the area before going elsewhere to finish the day's hunt. An average of 36 per cent of game farm birds were killed when there was a pressure of one hunter per 0.5 acre of hunting area.

Hunter success on the area was relatively poor. An average of 3.8 hours was spent by hunters in bagging a bird the first day, 14.5 hours the second day and 19.3 hours the third day. However, this relatively poor success per hunter was more than offset by the extremely high number of hunters using the area. These figures on the hours per bird bagged include both wild and farm-reared birds (Table 5).

Game farm birds constituted an average of 18.2 per cent and wild birds an average of 80.5 per cent of the harvest from the area. The game farm birds comprised a high of 23.3 per cent of the kill in 1947 and a low of 14.2 per cent in 1948 (Table 2).

Comparative success with and without dogs: There was only a slightly higher success by hunters using dogs over those not using dogs.

TABLE 5.—HOURS HUNTED PER PHEASANT BAGGED IN THE WEST WARREN EXPERIMENTAL AREA, UTAH, 1946–1950

| Year | Hours hunted per bird | | | |
|---|---|---|---|---|
| | First Day | Second Day | Third Day | Fourth Day |
| 1946.... | 4.57 | 10.45 | 11.00 | ..... |
| 1947.... | 6.36 | 20.12 | ..... | ..... |
| 1948.... | 1.23 | 10.70 | 45.60 | ..... |
| 1949.... | 3.50 | 13.24 | 16.35 | ..... |
| 1950.... | 3.27 | 17.90 | 24.00 | 12.50 |
| Averages | 3.78 | 14.48 | 19.33 | 12.50 |

The success with dogs in 1951 was only 1.02 birds per hunter while without dogs the average success was 0.98 birds per season, a difference not considered significant. It was believed that the heavy hunter pressures may have had a bearing on this, since practically all the area was thoroughly hunted.

## SUMMARY AND CONCLUSIONS

1. This study, covering the 6-year period 1946–1951, was conducted on the West Warren Experimental Area, Weber County, Utah, an area of 257 cultivated acres and approximately 1710 pasture and waste land acres with a high population of wild pheasants.

2. Pheasants were released at the rate of about 100 male birds per season with the exception of the first season when 268 were released. Releases of 20 birds each were made at two-week intervals beginning August 1 and continuing until a few days before the hunting season or until all the birds were released.

3. The rate of stocking was 39 birds per 100

TABLE 4.—GAME FARM PHEASANT RETURNS IN RELATION TO HUNTING PRESSURE

| Year | Number of hunter days | Game farm pheasants killed per hunter per season | Total pheasants killed per hunter per season | Acres of farm land per hunter day |
|---|---|---|---|---|
| 1946..... | 447 | 0.089 | 0.50 | 0.575 |
| 1947..... | 526 | 0.087 | 0.38 | 0.488 |
| 1948..... | 413 | 0.084 | 0.60 | 0.622 |
| 1949..... | 367 | 0.082 | 0.47 | 0.700 |
| 1950..... | 477 | 0.059 | 0.37 | 0.543 |
| Total..... | 2230 | | | |
| Averages..... | | 0.067 | 0.46 | 0.585 |

acres of cultivated crop land, much higher than normally made throughout the state.

4. From the 764 game farm pheasants released 211 birds were bagged giving a 27.6 per cent return. Highest returns of any year was 46 per cent of the birds in 1947 and lowest, 15 per cent in 1946.

5. Highest returns of any age group of birds was 60 per cent for 18-week-old birds released a week or less before the hunting season. Lowest returns were from 44-week-old birds released in the early spring. These were also released the longest time prior to the hunting season.

6. Birds released up to 4 weeks prior to the opening date of the season gave 40 to 60 per cent returns while those released more than 4 weeks in advance of the season gave less than 30 per cent returns.

7. Game farm birds constituted an average of 18.2 per cent of the harvest with a maximum of 23.3 in 1947 and a minimum of 14 in 1948. The average take of wild pheasants in the area was 80.5 per cent of the harvest.

8. A total of 2230 hunters used the study area during the 5-year period 1946–1950, an average of 446 hunters per season or a hunter per 0.57 acre of cultivated lands.

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## RABBIT DAMAGE TO OAK REPRODUCTION AT THE KELLOGG BIRD SANCTUARY[1]

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Incidental to studies of cottontail rabbit (*Sylvilagus floridanus mearnsii*) population dynamics on the Michigan State College Kellogg Bird Sanctuary near Battle Creek, Michigan it was noted that rabbit browsing on oak reproduction was extensive and severe. This prompted a brief study to determine the extent and effect of this damage.

Most oak reproduction was found in open areas which had been retired from agriculture about 25 years ago and have now grown into a grass-shrub stage of succession, which provides excellent rabbit habitat. Black oak (*Quercus velutina*) was by far the most abundant species of reproduction and also the dominant species in nearby woodlots, indicating that these abandoned farm lands may eventually revert to this type.

To rapidly determine the type and extent of rabbit damage, every young oak encountered while walking through various parts of the Sanctuary was examined. It was found that 89 per cent of 212 young oaks examined had been used as winter food by cottontails. Most damage was in the form of pruning and barking. Oak reproduction over four feet high was very uncommon.

To determine the effect of this injury, 68 trees were cut by the writer and the following data recorded for each tree:

1. Age
2. Average diameter one inch above ground level
3. Height at the beginning of the 1953 growing season
4. Number of main stems, *i.e.* leaders
5. Extent of rabbit pruning and/or barking
6. Presence or absence of heart-rot

Rabbit-damaged trees were cut with no attempt being made to select either heavily or lightly damaged trees. It is believed that this resulted in a representative sample. A disportionately high number of undamaged trees were cut so that a more adequate comparison could be made. The results of this comparison are shown in Table 1. It indicates that rabbit-damaged trees differ significantly from undamaged trees by having:

1. Slower rate of height growth

[1] The writer is indebted to Drs. George A. Petrides and Leslie W. Gysel of the Department of Fisheries and Wildlife, Michigan State College and to Dr. Arthur E. Staebler, Director of the Kellogg Bird Sanctuary, for suggestions concerning preparation of this paper.

TABLE 1.—COMPARISON OF RABBIT-DAMAGED WITH UNDAMAGED OAK REPRODUCTION

| Characteristics | Rabbit damage absent | | | Rabbit damage present | | | Statistical significance of difference |
|---|---|---|---|---|---|---|---|
| | Mean | Standard deviation | Range | Mean | Standard deviation | Range | |
| Height-growth rate inches/year | 7.6 | ±4.0 | 2.7–16.7 | 3.2 | ±1.5 | 0.7–6.7 | *** |
| Diameter-growth | 2.9 | ±2.1 | 0.9*–5.7 | 2.2 | ± .3 | 1.1–3.7 | ** |
| Number of main limbs present | 1.9 | ± .3 | 1–3 | 3.9 | ± .13 | 1–7 | *** |
| Maximum crown width, inches | 13.1 | ±9.8 | 4.5–36 | 9.5 | ±3.7 | 3–21 | **** |
| | Sample size | Number having characteristic | Per cent | Sample size | Number having characteristic | Per cent | |
| Heart rot | 24 | 4 | 17 | 44 | 32 | 73 | *** |
| Dead main limbs present | 18 | 1 | 6 | 33 | 18 | 55 | *** |

* Severe worm damage apparently retarded growth of this tree. The next slowest growth was 1.6 m.m./year.
** Significant at the .01 level of probability.
*** Significant at the .001 level of probability.
**** Not quite significant at the .05 level of probability.

2. Slower rate of stem diameter growth
3. More main limbs per tree
4. A greater occurrence of dead main limbs
5. A higher incident of heart-rot

In addition, it was found that when the height of rabbit-damaged trees was graphed against age, no correlation existed. In contrast, undamaged trees displayed a positive correlation between age and height. It was apparent that many young oaks had had each year's growth pruned back annually for many years.

Oak is the most important forest type in southern Michigan (Gysel and Arend, 1953). Also, lack of adequate reproduction is one of the most important problems in the management of oak woodlots (Society of American Foresters, 1953). Therefore, locally at least, rabbit damage to oak reproduction may have an important effect in hindering the perpetuation of oak as a dominant species.

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